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WITH NINETEEN PLATES  
and 217 Text-figures.

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## CORRIGENDA.

(Volume lxii.)

Page ix, line 14, for *Fuviatile* read *Fluviatile*Page xviii, line 25, for *determinaitons* read *determinations*Page 19, line 10 from bottom of page, for *fulvithorax* read *fulvicoxa*Page 155, line 6 from bottom of page, for *brimblecombei* read *brimblecombi*Page 167, line 6, for *brimblecombei* read *brimblecombi*Page 168, line 2, for *brimblecombei* read *brimblecombi*

THE STRUCTURE OF GALLS FORMED BY *CYTTARIA SEPTENTRIONALIS*  
ON *FAGUS MOOREI*.

By JANET M. WILSON, B.A.

(Plates i-ii; twelve Text-figures.)

[Read 31st March, 1937.]

The parasitic fungus *Cyttaria* has been found attacking different species of *Fagus* in South America, Australia and New Zealand. Two species have been recorded in Australia, *Cyttaria Gunnii* Berk., which grows on *Fagus Cunninghami* Hook. in Victoria and Tasmania, and *Cyttaria septentrionalis* Herb. on *Fagus Moorei* F.v.M. in New South Wales and southern Queensland. *C. septentrionalis* was first described by Herbert (1932) from the MacPherson Ranges, on the southern Queensland border, and was later recorded by the writer (1935) from Barrington Tops, Mt. Royal Ranges, north-west of Newcastle, N.S.W.

*Cyttaria* has been placed in the family Cyttariaceae, an inoperculate family of the Pezizales.

*Materials.*

The material used in this investigation was collected on 28th August and 6th October, 1935, near the summit of Barrington Tops, New South Wales. Microtome sections of the gall were stained by the iron-alum haematoxylin method, and with gentian violet and orange G. These showed the details of the mycelium. Hand sections were also made and stained with lacto-phenol-cotton blue. By this method the mycelium and cytoplasm stained a bright blue and were differentiated from the host cells. The distribution of the fungus in the tissues could thus be traced.

*Gall Formation.*

Infection by the fungus causes certain modifications of the host which result in the formation of hard woody galls. Galls develop on all infected stems and branches which are undergoing secondary thickening. Secondary tissues only are infected.

*Macroscopic Examination of Galls.*

The galls vary from about half an inch to a few feet in length, and from half an inch to about eighteen inches in diameter. They may be long and narrow (Plate i, figs. 1, 2) or short and round (Plate i, fig. 3). Long narrow galls are the commoner, and their shape is due to the fact that infecting mycelium spreads along the cambium chiefly in one direction, parallel to the long axis of the stem. It extends further each year, so that the galls are widest in the centre, tapering off towards each end. The long narrow galls are often somewhat twisted round the stem, following the natural twist of the grain of the wood. In the round short galls the parasitic mycelium has not travelled longitudinally to any extent from the centre of infection.

A transverse section across a gall shows that all the tissues of the stem are not invaded (Text-fig. 1). One or more irregularly wedge-shaped areas of infected tissue can be seen in the stem (A in Text-fig. 1d) extending from the cortex nearly to the pith. Each infected section of the stem is generally the result of one primary infection, but compound galls, which owe their origin to two or more primary infections close together, are not uncommon. This condition is shown by the gall illustrated in Plate i, figs. 4a and 4b. This gall has four components which can be seen externally at A, B, C and D as erumpent areas separated by normal bark. The internal extent of the infected tissues is shown in Text-figure 1, a-h, representing transverse sections of the gall taken at intervals of one inch. Infected tissues are shaded, the unshaded parts representing normal xylem. The centre of the stem is marked in each case by a small circle. It can be seen that each infected area may be split up by narrow bands of normal xylem (A in Text-fig. 1a), but all are the result of a single infection.

Usually the infected area or areas are on one side of the stem only, giving it a very asymmetrical appearance. This is because infection causes an increase in the size of the tissues near, but not in, these infected areas, making the wood some distance from it on the infected side of the stem much thicker than on the uninfected side (Text-figs. 1 and 2). The twisted appearance of some galls is due to the occurrence of several infections fairly close together.

#### *Age of Galls.*

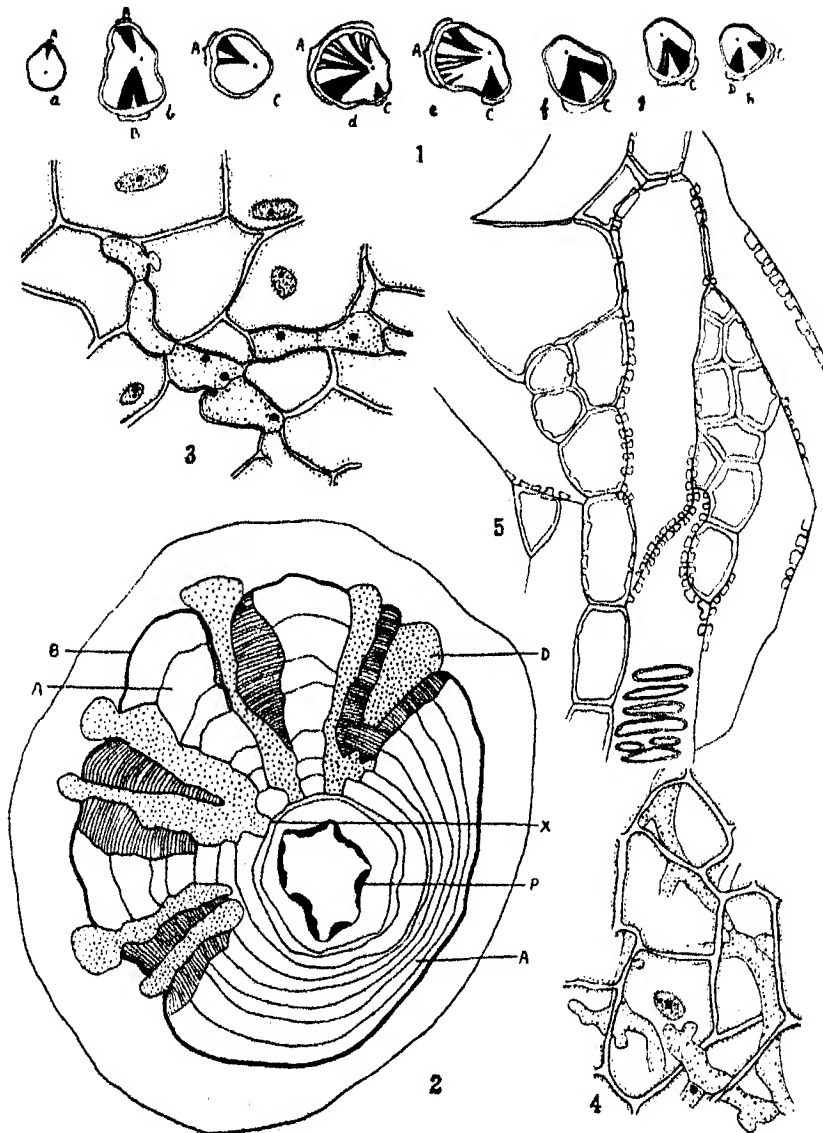
The mycelium is perennial and grows each year during the most active growth period of the host tree. The annual rings are fairly well marked in the uninfected wood of the gall (Plate i, fig. 5). Large vessels are formed each spring, but at the end of the active period of growth thicker-walled tracheids and fibres are formed. The age of any twig or branch can therefore be calculated. By making transverse sections of a gall, a point can be found where the infected tissue most closely approaches the pith. This has been taken to be the point at which infection first took place. It has always been found that infected xylem is present in the second annual ring, indicating that the fungus first becomes active at the commencement of the second growing season. By tracing the inward extent of the fungus in sections progressively nearer the ends of the gall, a region can be found where the infected tissue extends only to the beginning of the third annual ring (X in Text-fig. 2). The distance between this and the area of initial infection gives the rate of growth of the fungus longitudinally along the cambium in one year. Similarly the growth rate in subsequent years can be found. It was found that the growth rate of the fungus in the stem varies considerably from a few millimetres to over 1 centimetre per year.

#### *Tissues Infected.*

The tissues susceptible to infection are the cortex, phloem, cambium and secondary xylem. Of these the xylem is the chief tissue infected and forms the bulk of the gall.

(A). *The Secondary Xylem.*—Three types of cells occur in the secondary xylem of the gall: (1) Normal xylem elements; (2) Cells which contain the fungal hyphae; and (3) Cells which do not contain hyphae, but are modified in such a way that they do not develop normally.

(1). Normal xylem consists of vessels, tracheids, fibres and a little parenchyma, interrupted at intervals by xylem rays one or two cells wide and about twelve cells deep (Plate i, figs. 5, 6, 7). Fairly well defined annual rings



Text-figs. 1-5.

1.—Series of transverse sections one inch apart from the compound gall shown in Plate I, figs. 4a and 4b, to show the areas of the stem occupied by the various components of the gall. Infected areas are shaded and the centre of the stem is marked by a small circle. The various components are shown at A, B, C and D.  $\times 0.5$ .

2.—Transverse section of a gall near the centre of infection. A, normal xylem; B, cambium; C, infected tissue; P, primary xylem; X, point at which infection extends to third annual ring.  $\times 12$ .

3-4.—Sections of infected cells showing mycelium.  $\times 720$ .

5.—Transverse section of portion of a gall showing tracheidal cells.  $\times 720$ .



are shown (A in Plate I, fig. 5), since there is a definite period of rapid growth each spring following a period of inactivity of the cambium during the winter. These cells in themselves are quite normal, but between infected areas, and for a short distance on either side of infected areas, they are produced in greater numbers than in other parts of the stem (Text-fig. 2), thus giving the increased diameter referred to above.

(2). The tissues containing fungal mycelium resemble ordinary parenchyma. The cells are isodiametric, with fairly thick, but not lignified, walls and they show no prominent pitting (Text-figs. 3, 4; Pl. I, fig. 5; Pl. II, figs. 8, 16). These cells originate as xylem elements. They become infected with mycelium as they are cut off from the cambium and their normal process of development is modified by the presence of the fungus. Instead of acquiring lignified walls and losing their contents and so becoming vessels, fibres or tracheids, or developing into parenchyma or ray cells, they elongate slightly, but otherwise remain little altered.

(3). The mycelium is not itself found in any other type of cell, but its presence causes modifications in the adjoining xylem (B in Text-fig. 2). These modifications become more marked as the gall increases in age. Young xylem elements in the vicinity of infected cells develop into tracheid-like cells. In an old gall these cells often occupy a larger area than do the infected cells, and it is to them that the gall owes much of its increase in size over that of the stem (Text-fig. 2). In the mature state these cells vary much in size and shape (Text-figs. 5 and 12). The modified cells are usually several times longer than broad (Plate II, fig. 8). Plate II, fig. 8 shows infected cells (A) bordered by modified xylem (B) and finally unmodified xylem (C). Plate II, fig. 12, shows tracheidal cells at the upper edge of an infected area bordered on both sides by normal xylem. These tracheidal cells tend to dovetail into one another. This is shown especially well in tangential section (Pl. II, fig. 9) and in transverse section (Text-fig. 5). Their walls are lignified and show prominent scalariform pits with very narrow borders (Pl. II, fig. 10 and Text-fig. 5). The direction of growth of the tracheidal cells varies considerably as is shown in transverse section (Pl. II, figs. 10, 11, 8, 12) and longitudinal section (Pl. II, fig. 9). In these sections cells are seen both longitudinally and transversely arranged. The radial arrangement of the xylem is therefore entirely lost in the region where they occur, and it becomes more irregular the older the gall (Pl. II, fig. 12).

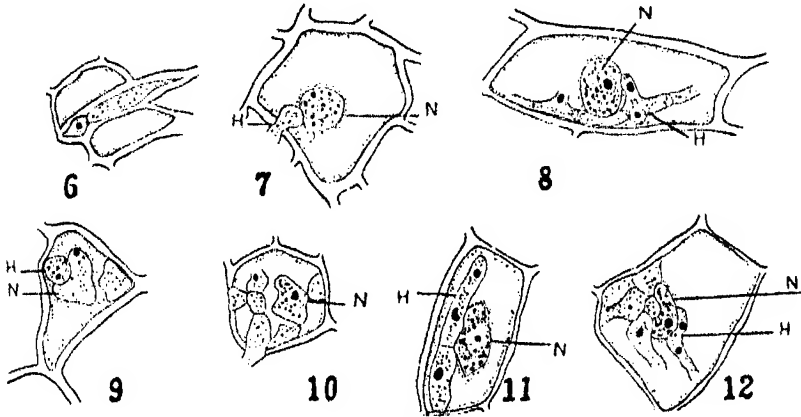
Starch grains are present in great abundance in some of the young tracheidal cells (Pl. II, fig. 14).

Areas of uninfected xylem are often seen arising in an area of infected xylem (Text-figs. 10, 1d, A in Plate I, fig. 5). These are mostly wedge-shaped with the thin edge inward. Each must have originated from a cell of the cambium in the infected region which by chance was uninfected and therefore able to give rise to uninfected cells.

(B). *The Cortex and Phloem.*—In the primary cortex and phloem, infection produces a result resembling in some respects that produced in the xylem. The cells which contain the mycelium are similar in all respects to the infected cells in the xylem. The reaction of the phloem and cortex to fungal invasion differs from that of the xylem principally in that uninfected cells are in no way modified. Infection of the phloem causes an increase in the number of normal cells in the neighbourhood of the infected cells, thus increasing the size of the phloem tissue (Plate I, fig. 7).

The secondary cortex is lacking or only a few cells in width, and appears never to be infected (Plate II, fig. 15).

(C). *The Cambium*.—The infected cells in the cambium are similar to infected cells in other tissues (B, Plate I, fig. 5). Though the cambium seems to be the centre from which other tissues are infected, the mycelium does not spread in a lateral direction along it further than it does in the xylem or the phloem, nor does it cause any modification of neighbouring cambial cells. Modified tracheidal cells are derived from uninfected cambium which at the same time produces uninfected phloem on the other side. In this case the phloem cells are usually produced at a more rapid rate than in uninfected stems.



Text-figs. 6-12.

6.—Section of an infected cell showing intercellular mycelium.  $\times 960$ .

7-12.—Sections of infected cells showing effects of haustoria (H) on host nuclei (N).  $\times 960$ .

#### *The Mycelium within the Gall.*

The vegetative mycelium of *Cyttaria septentrionalis* is fairly evenly distributed throughout the tissues it invades, except just below fruiting bodies, where the host cells are more or less completely filled with mycelium. Plate I, fig. 5, shows that no massing of fungal mycelium occurs in the wood.

The mycelium is septate and moderately thin-walled (Text-fig. 3), but the cells vary considerably in length. They usually appear to be uninucleate. This condition does not always obtain in the haustoria, which frequently show the presence of 2 or 3 nuclei (Text-figs. 8, 11, 12). The protoplasm is homogeneous and not very dense (Text-fig. 3).

The mycelium seems to be able to make its way either between the cells or across them, i.e., it is both intra- and inter-cellular (Text-figs. 4, 6). At the point where it enters the cell through the wall it may show a slight constriction (Text-fig. 7), but this is not invariable (see also Text-fig. 4). The intercellular mycelium sends into the cells haustoria which are irregular in shape and often prominently lobed (Text-figs. 9 and 10).

#### *The Effects of the Mycelium on Host Cells and Tissues.*

The hypha or haustorium, having entered the cell, usually approaches the nucleus (Text-fig. 4) and finally comes into contact with it (Text-fig. 7), or coils

partially round it (Text-fig. 8). This causes, in most cases, considerable enlargement of the host nucleus. Sometimes a definite change in the shape of the nucleus is apparent; it may become elongated, lobed or kidney-shaped (Text-figs. 9, 11, 12). The fungus does not appear to destroy the nucleus of the infected xylem or phloem cells, and, as far as has been observed, the host cells of these tissues are not eventually killed. Just below a fruiting body, however, the cortical cells become so filled with mycelium that the nucleus and all the contents are completely absorbed and replaced by the fungal mycelium.

The result of infection on the tissues as a whole is a general enlargement of part of the stem, i.e., the formation of a hyperplastic gall, which is due to increase in the number of the cells and not to increase in size of the existing cells (i.e., hypertrophy).

The greatest increase takes place in the xylem and phloem, the primary cortex seldom being heavily infected. Text-figure 2 shows the normal proportion of infection in each tissue.

The increased rate of cell production in the phloem causes the bark covering the gall outside an infected area to become thicker than outside normal wood (Plate II, figs. 15, 16), even when it contains no mycelium. It is, however, frequently ruptured by the rapid expansion of the tissues beneath it, and, in addition, shows various scars left by the fruiting bodies of previous years. The phellogen is a very narrow band and is lacking over the ruptured areas.

Infection does not seem to cause the death of a tissue.

#### *The Effect of Gall Formation on the Growth of Fagus.*

The formation of galls on the branches of *Fagus* seldom seems to do the tree serious injury. Since no tissues are killed and since, in most cases, there is a considerable part of the stem at the level of the gall which contains normal tissues, the passage of food materials and water up and down the stem is not unduly restricted. Very large and apparently healthy trees were observed to be heavily covered with galls (Plate I, fig. 1). In one case a large gall was observed on the main trunk of a tall living tree within a few feet of the ground.

#### *Suggested Means of Infection.*

A macroscopic examination shows that large branches have only old galls, never young ones. The young galls are found only on young stems, indicating that primary infection takes place only when the stem is young. It would be impossible for mycelium to penetrate the hard bark of an old stem. If an invading hypha entered through a lenticel, it would still have to cross the cortex, in which there are one to several bands of stone cells, and the phloem before it could infect the cambium, which has been shown to be the centre of infection in the gall.

There is no trace of fungal mycelium in the primary xylem or pith. In the galls examined the first trace of infection occurs in the xylem and phloem of the second year's growth. These observations suggest the following hypothesis as to how infection may take place. During the late spring and early summer, October to early December at Barrington Tops, the spores of *Cyttaria* mature and are blown through the air in great numbers. At the same time the young shoots of *Fagus* are elongating and are still covered with a somewhat hairy epidermis. Secondary thickening commences in these young shoots towards the end of the growing season. The spore, alighting on the epidermis of the young shoots, germinates and the germ tube penetrates the epidermis and the cortex. The

mycelium then probably remains dormant until the beginning of the next spring, either in the cortex or in one of the medullary rays, or, most probably, in the young cambium. When secondary growth begins in the following year, it infects the young xylem and phloem cells as they are developing, and this process goes on yearly. The mycelium also infects the cambium in a longitudinal direction.

#### *Summary.*

*Cyttaria septentrionalis* Herb. is a parasitic fungus which infects the stems of *Fagus Moorei* in New South Wales.

Infection results in the formation of galls very varied in shape and size.

Wedge-shaped areas of infection occur in the stem. Usually one side of the stem is not affected, but contains normal tissue. A gall may be the result of one or more infections and thus may be called simple or compound.

The age and growth-rate of an infected area can be calculated by observing its relationship to the annual rings of the stem.

The tissues infected are the primary cortex, secondary phloem, cambium, and secondary xylem. The xylem contains three groups of cells, normal elements, parenchymatous cells containing mycelium, and tracheidal cells, containing no mycelium but modified as a result of the infection of the neighbouring cells. Starch is present in the young tracheidal cells.

The cambium, phloem and primary cortex consist only of normal cells and parenchymatous cells containing mycelium. A smaller area in the cortex is infected than in the xylem, but in old galls the increase in phloem tissue is proportionate to that in the xylem.

The mycelium is septate, thin walled and 1- to 3-nucleate. It is both inter- and intra-cellular, and produces irregularly-shaped haustoria. It is distributed evenly throughout the tissue it invades, except just below the fruiting bodies, where it almost completely fills the cells.

The haustorium approaches the nucleus and partially coils round it, causing its enlargement or lobing, though it does not destroy it. The host cells are not killed. In some cases cells appear to arise which are free of infection.

Infection of the stem causes enlargement due to increase in the number of cells. This is most pronounced in the xylem and phloem, very little increase taking place in the other tissues. The bark is thicker outside infected areas because of the increase in the amount of the phloem, and is much ruptured and scarred.

Galls do not appear to cause serious damage to, or restrict the growth of, the trees on which they grow.

Macroscopic and microscopic examinations suggest that the mycelium from the germinating spores enters the young stem during the late spring or early summer, just before secondary thickening begins or while it is taking place. The mycelium then probably remains dormant in or near the cambium until the beginning of the second year's growth. It then proceeds to infect the young xylem and phloem cells and continues to do so from year to year. The mycelium also travels along the cambium in a longitudinal direction.

In conclusion, the writer wishes to thank Assistant Professor J. McLuckie and Miss Lillian Fraser for their interest and helpful suggestions throughout the course of this work.

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WILSON, J. M., 1935.—A species of *Cyttaria*, apparently *C. septentrionalis*. *Proc. Linn. Soc. N.S.W.*, lx (5-6), pp. xlii-xliii.

## DESCRIPTION OF PLATES I-II.

## Plate I.

- 1.—Small branch of *Fagus Moorei*, showing numerous galls.  $\times 0.07$ .
- 2.—Part of a branch of *Fagus Moorei* showing a long, narrow gall.  $\times 0.6$ .
- 3.—Part of a branch of *Fagus Moorei* showing a round, short gall.  $\times 0.6$ .
- 4a, 4b.—Two views of a compound gall. The various components of the gall are shown at A, B, C and D. a, b, c, etc., mark the places from which the sections represented diagrammatically in Text-figure 1 were cut.  $\times 0.6$ .
- 5.—Portion of a transverse section of a gall showing areas infected by *Cyttaria*. A, wedge-shaped area of uninfected xylem; B, infected cambium; C, annual rings; D, infected xylem.  $\times 37$ .
- 6.—Radial longitudinal section of portion of a young stem of *Fagus* showing normal wood structure.  $\times 210$ .
- 7.—Tangential longitudinal section of portion of a young stem of *Fagus* showing normal wood structure.  $\times 210$ .

## Plate II.

- 8.—Transverse section of portion of a gall. A, infected cells containing mycelium; B, tracheidal cells; C, normal xylem.  $\times 85$ .
- 9.—Tangential longitudinal section of part of an old gall showing tracheidal cells.  $\times 31$ .
- 10-12.—Transverse sections of parts of galls showing tracheidal cells. 10,  $\times 375$ ; 11,  $\times 85$ ; 12,  $\times 45$ .
- 13.—Transverse section of part of an old gall showing the loss of radial arrangement of the xylem.  $\times 45$ .
- 14.—Transverse section of part of a gall showing starch grains in the young tracheidal cells.  $\times 45$ .
- 15.—Transverse section of part of a normal stem of *Fagus* showing phloem (P) and phelloderm (X).  $\times 85$ .
- 16.—Transverse section of infected phloem showing increase in number of cells due to infection.  $\times 85$ .

# ENTOZOA FROM THE AUSTRALIAN HAIR SEAL.

By T. HARVEY JOHNSTON, Professor of Zoology, University of Adelaide.

(Twelve Text-figures.)

[Read 31st March, 1937.]

In January, 1923, Professor F. Wood Jones, F.R.S., led a small biological party which visited Pearson Island, lying about twenty-five miles off the west coast of Eyre's Peninsula, South Australia. Amongst the material obtained were some entozoa collected by Professor J. B. Cleland from the Australian hair seal, *Arctocephalus forsteri* (Lesson). No species of parasite has, as yet, been recorded from our pinnipeds. Amongst the ectozoa known to occur on the hair seal may be mentioned a Pediculid, probably an undescribed species of *Antarctophthirius* or *Echinophthirius*. The entozoa referred to in this paper belong to three species, namely, a cestode, *Diphyllobothrium arctocephalinum*, n. sp.; a nematode, *Contracaecum osculatum* (Rud.); and an echinorhynch, *Corynosoma australe*, n. sp. The types of the new species have been deposited in the South Australian Museum, Adelaide.

## DIPHYLLOBOTHRIUM ARCTOCEPHALINUM, n. sp. Figs. 1-7.

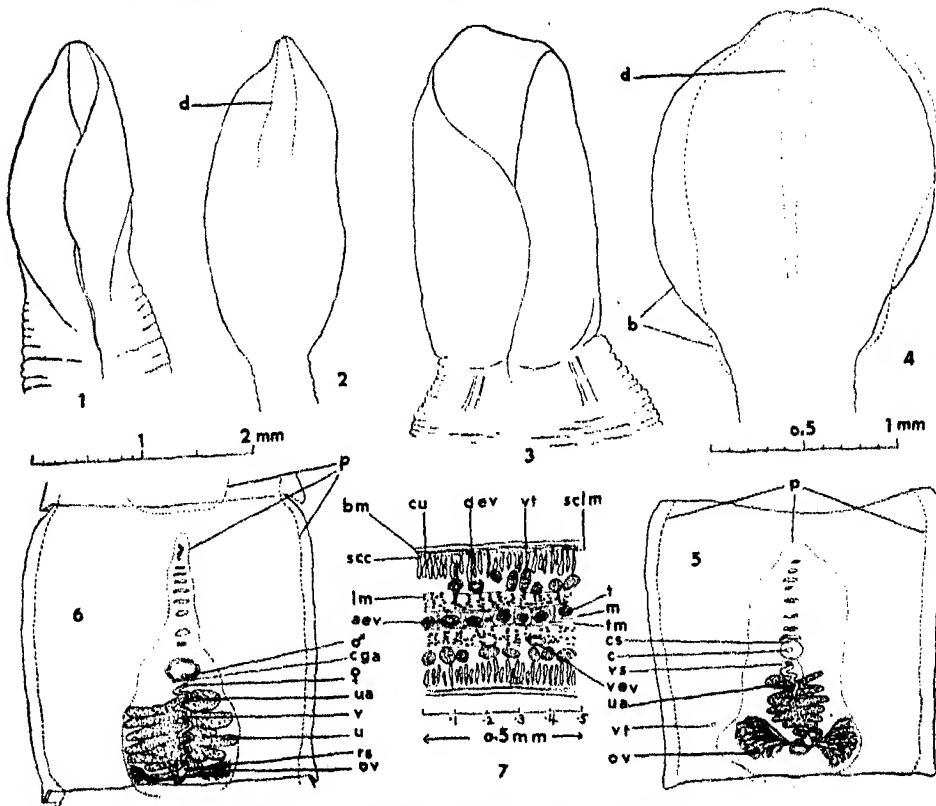
In the intestine of *Arctocephalus forsteri* there was found a tangled mass of cestodes whose separation resulted in some fragmentation. A specimen bearing a scolex was 17 cm. long, the terminal 5 centimetres bearing eggs. A fragment of another strobila was about 44 cm. in length, approximately 40 cm. of it being ovigerous. If one matched these two fragments according to the sizes of their segments and their reproductive condition, the total length of an unbroken strobila would be not less than 54 cm., of which more than 40 cm. would probably be egg-bearing. Segments which had just become ovigerous were nearly one millimetre long and 5 mm. broad, and sufficiently overlapping the succeeding proglottis to give a slightly serrate margin to the strobila. In strongly contracted strobilae the serrations were much more pronounced. Segments in the mid-region of the scolex-less strobila, mentioned above, were about 5 mm. wide and 2.5 to 3.1 mm. long, whilst those near the posterior end measured 6 mm. in width by 3.7 mm. in length.

Another fragment, 36 mm. long, possessed a markedly crinkled margin and all its segments were egg-bearing, but they were considerably wider and shorter anteriorly, 6 mm. and 1.5 mm. respectively, than in the corresponding portion of the other strobila. The length gradually increased to 3 mm. in segments at the end of specimen, the breadth becoming 8 mm. Hence, at first sight, there appeared to be two species represented in the material, but the anatomy was similar and the differences in dimensions were due no doubt to the state of muscular contraction.

The scolex was narrower than the succeeding segments, but, when viewed laterally, was seen to be at least twice as thick as the neck region. The dimensions varied according to the state of contraction. When relaxed the breadth was

0.65 mm. and the length from the tip to the posterior end of the bothrial groove was 1.5 to 2 mm., the very thin edge of one bothrium slightly overlapping the other (figs. 1, 2). The maximum dorsoventral thickness was 0.75 cm. The groove in some specimens extended back above the earliest segments. In one scolex the bothria were rather wider and the groove shorter, the organ being 0.95 mm. in breadth, 2.0 mm. in length, with a thickness of 1.5 mm. (fig. 3), the anterior extremity thus being almost round when viewed laterally (fig. 4).

There is a very short unsegmented neck, but since the bothrial grooves enter it, this region should perhaps be regarded more correctly as merely the narrowed



Figs. 1-7.—*Diphyllobothrium arctocephalum*.

1, 2, Scolex, face and lateral views; 3, 4, a larger scolex, face and lateral views; 5, segment in which the uterus has just become egg-bearing, ventral; 6, mature segment, ventral (scale above); 7, portion of transverse section of mature segment to show relation of various glands and ducts.

(Figs. 1-5 drawn to scale indicated below Fig. 4.)

References to lettering.—aev, ♀ accessory excretory vessel; b, bothrium; bm, base-ment membrane; c, cirrus; opa, common genital aperture; cu, cirrus sac; cu, cuticle; d, tissue at side of scolex, between bothria; dev, dorsal excretory vessel; lm, longitudinal musculature; m, medulla; ov, ovary; p, boundary (dotted) of vitelline zone; ra, receptaculum seminis; scc, subcuticular cells; solm, subcuticular longitudinal muscle fibres; t, testis; tm, transverse muscles; u, uterus; ua, uterine aperture; v, vagina; va, vaginal aperture; vev, ventral excretory vessel; va, vesicula seminalis; vt, vitelline glands.

portion of the scolex. The breadth of this part is from 0.7 to 1.9 mm., with a thickness of 0.3 to 0.6 mm.

The common genital opening lies in the midline ventrally at, or just behind, the mid-length of the segment. The opening is a transverse or rounded slit, according to the degree of retraction or protrusion of the cirrus. Into the posterior wall of the genital atrium there opens the much smaller slit-like vaginal aperture, whose walls are well chitinated. Behind these openings is the tocostome or uterine aperture situated a little to one or other side of the median line (or sometimes in the mid-line) as a transverse slit at whose narrow base the metraterm terminates. In whole mounts the mid-region of each ripe or maturing segment shows the presence of differentiated tissue, apparently medulla, in front of the cirrus sac and extending almost to the anterior end of the proglottis. A series of short transverse grooves or folds are commonly associated with this region, but no differentiated organs were noticed there.

Transverse sections reveal the presence of a thick cuticle below which is a narrow, well-defined, less deeply staining, basement membrane, succeeded by sub-cuticular structures, the very large elongate fusiform cells being a marked feature. The sub-cuticular longitudinal muscle fibres are fairly well marked, but the transverse fibres are very minute. The cortex is occupied largely by the abundant vitellaria arranged in a single row dorsally and ventrally. The main longitudinal musculature forms a wide zone, the individual fibres being powerful and arranged more or less in small groups not completely separated to form distinct bundles. The transverse muscles are much less deeply staining. Dorso-ventral fibres are weakly developed. The medulla is relatively very narrow and contains many calcareous corpuscles. It is occupied largely by the testes, ovary and uterus.

The main excretory canals are remote from the margins of the strobila, both have a wavy course, and the narrower dorsal vessel lies nearer to the median line of the segment. Both sets of canals have muscle fibres in their walls. Transverse canals are absent, but small sinuous branching canals pass from the main channels into the tissues. Sometimes these branches are large and, when seen in transverse section, resemble the main canals in size. In addition to the canals just referred to, there is, on either side, lying in the middle of the medulla just inwardly from the level of the dorsal excretory canal, a very definite canal with cuticular walls and abundant fine longitudinal fibres (apparently muscular). It has a sinuous course like the other vessels and appears to be a supplementary excretory canal, since communication with other systems has not been traced. The ovarian lobes may extend laterally to the vicinity of these canals and actually overlie them dorsally. The tissue surrounding them is more differentiated than that around the ordinary excretory ducts. Their position suggested that they might be the two vasa deferentia, but the failure to trace any connection with the vesicula seminalis seems to negative the suggestion.

The testes did not stain in whole mounts, but were obvious in sections, though the state of fixation of the material was not sufficiently good to allow one to study these organs satisfactorily. They are very numerous and occupy most of the medulla in the region where they occur, and they tend to approach its upper border. Their boundary is much less sharply defined than that of the vitellaria. They measure 0.03-0.046 mm. in diameter, these dimensions being based on their appearance in transverse and horizontal sections. They are restricted to two definite testicular fields which are widely separated in the mid-region of the segment, but which join to form a very narrow band near the anterior margin. The testicular and vitelline zones seem to coincide, except laterally, where the



medulla is absent. The yolk glands lie above and below the testes and occur almost to the lateral margin of the segment. A considerable pyriform area with its base in the posterior part of the proglottis is devoid of both these glands, but is occupied in its hinder half largely by the mature uterus.

Above the anterior portion of the uterus, as well as in front of that organ, is the large, elliptical, rather thick-walled, vesicula seminalis, about 0.23 mm. long and 0.015 mm. wide, lying somewhat obliquely. From it there issues a short narrow ejaculatory duct surrounded by the large muscular, circular, or rather spherical, cirrus sac whose outer boundary is ill-defined. This sac is ventral from the vesicula. The everted cirrus is about 0.1 mm. long and 0.05 mm. in diameter, narrowing towards its free end. There is a definite atrium when the organ is fully retracted, the male pore lying in front of the vaginal aperture which is located on its posterior wall.

The vagina is well chitinized in the vicinity of the genital pore and passes backwards a very short distance and then upwards below the cirrus sac, becoming suddenly widened and thrown into a number of very thin-walled convolutions in a horizontal plane, but these coils do not extend very far on either side of the midline as the organ makes its way posteriorly immediately below the uterus, close to whose ventral wall it lies pressed. Just in front of the ovary, the vagina forms a rather large receptaculum which is twisted or curved and extends below and just behind the ovarian bridge to become connected with the fertilizing duct by a very narrow short canal.

The ovary does not stain readily in whole mounts, and is best studied in sections. It lies in the posterior portion of the segment, closely behind the uterus. The main mass on either side is of a delicate branching structure whose branches may unite to form a reticulum as they radiate outwardly and forwards. The lobes extend practically to the testiculo-vitelline region and tend to occupy the upper portion of the medulla, whereas those parts nearer the midline lie ventrally in the medulla, the narrow ovarian bridge lying ventrally from the hind portion of the uterus. An oocapt appears to be present. The short oviduct is soon joined by the receptaculum and the fertilizing duct now formed is joined by the rather wide yolk duct and then surrounded by the mass of shell glands. The canal now becomes curved and bent on itself, and then suddenly widening into the uterus which passes forwards and is thrown into a series of about eight to ten transversely-lying coils or loops. As the organ becomes more densely packed with eggs it becomes more rosetta-like and swollen and the individual loops less distinct. The terminal loop is surrounded by thickened walls as it passes directly ventrally, the metraterm ending at the uterine pore some distance behind the common genital opening, and frequently a little to one or other side of the midline. Eggs are elliptical, measuring 0.052 to 0.057 mm. long by 0.035 to 0.038 mm. wide.

Yolk glands are extremely numerous and very small when seen in surface view, where they are commonly elongate in the direction transversely to the longitudinal axis of the segment. The vesicles are restricted to form two wide lateral zones which approach in the anterior half of the segment and eventually join to form a narrow band. They occupy a large part of the cortex ventrally and dorsally between the inner ends of the subcuticular cells and the main longitudinal musculature. They measure 0.030 to 0.057 mm. in maximum length by 0.01 to 0.013 mm. in width, and 0.030 to 0.040 mm. in dorsoventral diameter. The two main vitelline ducts pass inwards just behind, or just below, the ovarian bridge and unite to form a short common duct which enters the fertilizing duct.

The present species can be separated readily from *D. latum*, *D. cordatum*, *D. fuscum*, and *D. ranarum*, by the fact that in these species the uterine loops extend forwards to the sides of the genital pore. Though our species resembles *D. mansoni* and *D. houghtoni* in this feature, it differs from them in the arrangement of the loops. From *D. houghtoni* it differs also in the distribution of the testicular and vitelline fields, but it resembles *D. mansoni* in these respects. Baylis (1929) stated that in *D. mansoni* the very numerous testes were not arranged in distinct lateral fields, but Faust's figure (1930) indicates that they are. The form of the scolex and uterus, as well as the position of the genital pore, differentiate *D. arctocephalinum* from *D. reptans* and *D. ranarum* as described by Meggitt (1924; 1925). The shape of the scolex and of the neck region distinguishes our species from *D. cordatum*, *D. mansoni*, and many others. In *D. decipiens* the uterine loops are few and do not form a rosette. The dimensions of the strobila distinguish the Australian species from the small species described from southern seals.

The position of the common genital pore in relation to the length of the segment differentiates the species from nearly all others, since in *D. arctocephalinum* it lies either at, or behind, the midlength, whereas in others it is situated in front. The presence of the modified tissue extending forwards along the midline from the genital pore is a conspicuous feature in cleared, stained or unstained preparations. The dimensions of the eggs are different from those of all other species whose descriptions are available. The species which seems most nearly related anatomically is *D. mansoni*, but the main points of difference have been mentioned above. No cestode has been identified previously from Australian pinnipeds, though many are known from antarctic and subantarctic species.

The keys to species given by Meggitt (1924), Baylis (1929) and Sprehn (1932) have been consulted.

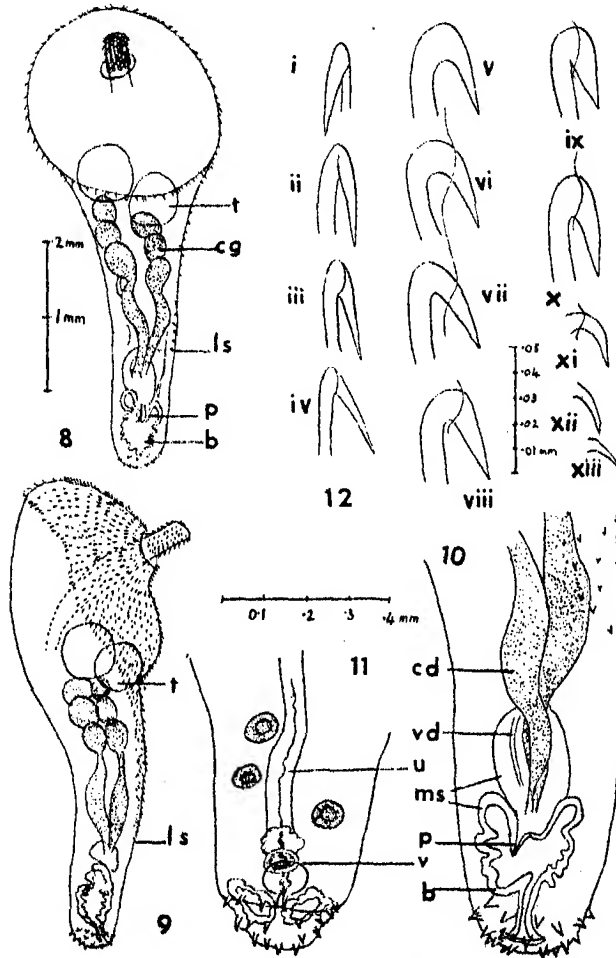
#### CONTRACAEUM OSCULATUM (Rud.).

This widely distributed nematode was represented by a young female specimen which exhibited the characteristic structure of the lips and the abundant fine striations at the anterior end. The species is known from northern seals as well as from several species which occur in the Subantarctic and Antarctic. It had not previously been recorded from Australian seals.

#### CORYNOSOMA AUSTRALE, n. sp. Figs. 8-12.

This minute parasite of *Arctocephalus forsteri* measures about 3.5 mm. in length, though specimens were examined ranging from 3 to 4 mm. Both sexes are similar in size and general form. The anterior body forms a rounded disc-like structure about 1.3 mm. in diameter, more or less flattened ventrally but arched dorsally, this region bearing very numerous, small, regularly arranged, spines. The rest of the body narrows rapidly and then becomes cylindrical for the last third of the total body-length where the diameter is 0.35-0.4 mm. The posterior end is rounded and is provided in both sexes with two circlets of spines (total 28-30) which are much larger than those on the rest of the body, and, as in other species of the genus, they give rise to triangular projections of the cuticle. Small spines similar to those on the dorsal and ventral surfaces of the disc are present on the ventral surface of the anterior part of the posterior body, the terminal quarter or fifth of the body-length being devoid of them except for the terminal group. The two best-known species, both occurring in eared seals (amongst other hosts) in the northern hemisphere, are *C. semerme* (Forss.) and

*C. strumosum* (Rud.). The Australian parasite resembles the former in general form and size, but the distribution of the small spines is more like that in *C. strumosum* where, however, from more than a half (Meyer's figure, 1932) to two-fifths (Lühe's figure, 1911) of the body-length ventrally is devoid of them. The ratio of the diameter of the disc to that of the cylindrical posterior body (based on figures published by Lühe and by Meyer) is about 2.4:1 in the case of *C. strumosum*; about 2:1 in *C. semerme*; and 3:1 in *C. australe*. The ratio



Figs. 8-12.—*Corynosoma australe*.

8, ventral view of male; 9, lateral view of male; 10, posterior end of male; 11, posterior end of female (dorsal view); 12, rostellar hooks belonging to one longitudinal row and marked i-xiii according to their position from the free end of the proboscis.

(Figs. 8 and 9 are drawn to the scale indicated beside 8; 10 and 11 to scale above 11.)

References to lettering.—b, bursa; cd, cement duct; cg, cement glands; ls, most posterior spine on ventral surface; ms, muscular sac ("markbeutel"); p, penis; u, uterus; v, vagina; vd, vas deferens.

of the length of the disc to the total body-length is about 1:2.3-2.6 in *C. strumosum*; 1:1.3-1.6 in *C. semerme*; and 1:1.4 in *C. australe*. *C. strumosum* measures about 5 to 6 mm., but sometimes reaching 9 mm. in length; while *C. semerme* is only about 3 mm. (3-5 mm.).

The arrangement of the caudal spines in *C. australe* resembles that in *C. constrictum* as figured by Van Cleave (1918) and quite unlike that in *C. semerme*, where they are very abundant and the series joins up with the ventral body spines.

The proboscis in *C. australe* is about 0.7 mm. long, narrowed in its anterior third, but widening to 0.2 mm. behind its mid-length and then narrowing only slightly towards its base. The proboscis length is thus about one-fifth that of the body, but in *C. strumosum* it is less than one-sixth, and in *C. semerme* it is more than one-quarter. The form of the organ in *C. australe* is rather slender, as in *C. strumosum*. There are 18 longitudinal rows of hooks, 13 to 14 in each row, a total of about 240. In *C. strumosum* there are also 18 rows, but each has 10 to 12 hooks; in *C. semerme* there are 22 to 24 rows each with 12 to 13 hooks. The hooks in *C. australe* are differentiated, the first four in each row being rather long, narrow, and pointed, the free portion measuring about 0.04 mm. in each case, while the basal part which lies in the proboscis is about 0.03 mm. in the first hook, increasing in succeeding hooks to become as long as the free portion in the fourth. From the fifth to tenth, the projecting portion is larger and more powerful, and the base as long as, or slightly longer than, the free part, but there is little, if any, increase in the length of the free portion (0.042 mm.; base 0.045 mm.). The eleventh, twelfth and thirteenth hooks (and fourteenth, if present) in each row are small and diminish slightly in length (0.025-0.023 mm.) and possess little or no basal portion. The arrangement of the hooks and their relative sizes are more like those of *C. strumosum* than those of *C. semerme*.

The proboscis sheath is double-walled, long and narrow (1.1 mm. by 0.25 mm.). The ganglion is in the vicinity of its mid-length. The lemnisci are thin, narrow structures each about half the length and breadth of the rostellar sheath. The delicate net-like lacunar system in the skin is typical of members of the genus.

The testes, each 0.04 mm. in diameter, are arranged one just a little more anteriorly than the other in that part of the body which contains the disc. The three pairs of narrow cement glands have an arrangement and form very like that in *Corynosoma semerme*. The lower end of the combined cement gland of each side is considerably swollen to form a fusiform structure. The ejaculatory duct opens into a short pointed penis projecting into an extensive bursa with folded walls when introverted. There is a large muscular sac ("markbeutel"). The male system closely resembles that of *C. semerme* as described by Lühe (1911) and Bieler (1914).

In the female, the uterus is long, narrow, and thick-walled, terminating in a short muscular folded vagina which appears to be made up of three short sections. The female aperture is terminal. In some specimens a "copulation cap" of cement was present resembling that figured by Van Cleave for *C. constrictum*. Eggs from the body cavity measure 0.075 to 0.085 mm. by 0.023 to 0.029 mm., with a short broad polar process at each end of the middle shell like that figured by Lühe and by Meyer.

In addition to *C. semerme* and *C. strumosum*, the following species have been described from seals: *C. hamanni* Linst. (*C. antarcticum* Rennie, *C. sipho* Raill. and Henry), and *C. bulbosum* Linst. from the Antarctic and Subantarctic; *C. reductum* Linst., a rather large immature form from the Arctic; and

*C. ambispinigerum* Harada from a Japanese *Phoca* sp. An account of the last-named is not available for comparison.

*Corynosoma* sp. is the only species of the genus recorded from Australian waters, having been reported by Johnston and Deland (1929) from a dolphin, *Delphinus delphis*, in St. Vincent's Gulf. Lühe (1911) mentioned having met with *C. semerme* in an immature condition once in *Otaria jubata* and once in *Spheniscus demersus*. The former is one of the South American seals and the latter is the South African penguin. *C. strumosum* is known from northern European seals and cormorants; Ball (1930) identified it from the Californian harbour seal (*Phoca richardii*), and Meyer (1932) stated that it occurred in *Phalacrocorax capensis* in former German South-west Africa.

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## NOTES ON GENUS CALLIPHORA (DIPTERA).

CLASSIFICATION, SYNONYMY, DISTRIBUTION AND PHYLOGENY.

By G. H. HARDY.

(One Text-figure.)

[Read 31st March, 1937.]

The difficulties met in taxonomic study are responsible for considerable differences in the treatment of Australian species of *Calliphora*. Many promising studies have proved inadequate to meet the needs of the research worker, and although progress is being made in the study of details of morphology, so far there is no generally accepted scheme for their classification.

Actually the work was undertaken first by Johnston and Hardy in 1922, but hardly any progress could be made owing to the lack of a suitable method of treating the terminalia. The problem was taken up again in later years by myself, but in the meanwhile material had been sent to Malloch, resulting in a paper that the late E. W. Ferguson (*These Proceedings*, III, 1927, p. xxiv) considered would solve the problem.

Some progress in the taxonomy of Australian *Calliphoras* was made in my paper of 1930, followed by another in 1932. The first of these brought considerable adverse comment at the time, but the attitude I had taken up in my treatment was subsequently acknowledged as leading somewhere. I do not think, however, that it was sufficiently recognized that the specific identities I had given rested largely on field observations which are difficult to set down in print. There were certain biological features arising from my studies, and I concluded that there are units in the Australian *Calliphoras* that cannot be isolated on terminalia alone, as far as yet known, but can be ascertained on colour and small structural characters that remain consistent for the species, not grading from one to another as at first would be supposed. These cases are represented by *C. rufipes* Macq. and *fallax* Hardy; by *C. augur* Fab. and *noctiva* Hardy; by *C. tibialis* Macq. and *perida*, a new species described below. I have not found any area where the first two meet, but the distributions of the others overlap.

The arrangements of the species within this genus, given by Professor W. S. Patton (1935) and by myself, are at variance. Patton makes three main groups based on the type of terminalia the species exhibit. On the other hand, as will be seen below, this is not so very different from my arrangement, the differences lying mainly in the position where the dividing lines are to be drawn. The true relationship will be gathered when all features of the fly are considered phylogenetically, and I would be in agreement with Professor Patton if he were to limit his view on affinities and if he did not make the development of the terminalia cover the whole species. There can be no doubt that Professor Patton, in arranging his studies along the line he has taken, is making a very big step in advance in our understanding of terminalia, but it is my impression that he carries his conclusions to a stage that is a too liberal rendering of his discoveries. A comparison of our respective methods of classification is to be gathered in the following list, where I have marked with an asterisk (\*) those species in which I have an intimate knowledge of terminalia. The list is only complete as far as

the subgenus *Proekon*. The remainder has been so confused in literature that I am unable at present to give a satisfactory account of the species concerned.

Subgenus ADICHOSIA Surcouf ochracea-group. *ochracea Schiner *nigrithorax Malloch	}	These three sections form the erythrocephala-group of Patton.
Subgenus CALLIPHORA Desvoidy erythrocephala-group *erythrocephala Meigen. (introduced)		
Subgenus NEOPOLLENIA Brauer stygia-group *stygia Fabricius *australis Boiduval *laemica White		
canimicans-group *canimicans Hardy *bezzii Hardy *auriventris Malloch	}	Together with <i>fuscofemorata</i> , these two sections form the canimicans-group of Patton.
sternalis-group *sternalis Malloch *deflexa Hardy		
rufipes-group *rufipes Macquart *fallax Hardy *milleri, n. sp. *fulvicoxa Hardy sp. (from Western Australia)	}	Together with <i>austratica</i> Malloch, these four sections form the augur-group of Patton.
tibialis-group *tibialis Macquart *perida, n. sp.		
Subgenus PROECON Surcouf augur-group *augur Fabricius *noctiva Hardy	}	Forms not yet dealt with by Patton mostly come here, but probably would be placed in the augur-group by him, or some separated into another section, canimicans-group, or elsewhere.
centralis-group *centralis Malloch  *falciiformis Hardy *macleayi Malloch *fuscofemorata Malloch		
Subgenus ONESIA Desvoidy dispar Macquart austratica Malloch and others	}	

Key to groups and species in genus *Calliphora*  
(combining Patton's leading discoveries).

1. Eyes hairy. Strut of aedeagus free.*	Ovipositor long. Abdomen yellowish.
.....	ADICHOSIA.—ochracea-group .....
Eyes bare .....	2

\* Patton states, under *ochracea*, that the strut is not free but "the end is attached to membrane". This must be an error, for on fresh material the struts will slip out of their membranous sockets quite readily, as in those of *stygia*.

2. Strut of aedeagus free. Ovipositor long ..... 3  
 Strut of aedeagus fixed to other parts by membrane throughout its whole length.  
 Ovipositor possibly always short ..... 4
3. Blue species. .... CALLIPHORA.—*erythrocephala*-group.  
 (One species only, *erythrocephala* Meigen, introduced.)  
 Densely tomentose and hairy species; abdomen brown .....  
 ..... NEOPOLLENIA.—*stygia*-group ..... 11
4. Densely tomentose species; abdomen brown ..... 5  
 Abdomen otherwise coloured ..... 8
5. Without secondary plates on male terminalia ..... 6  
 With secondary plates developed on male terminalia, these lying adjacent to acces-  
 sory plates, closing the genital cavity. Ovipositor not examined .....  
 ..... *sternalis*-group. .... 15
6. Strut reaching almost to apex of aedeagus which lies considerably to the rear of  
 the strut. Ovipositor not examined ..... *canimicans*-group ..... 13  
 Strut short in relation to the length of aedeagus so that the tip of the aedeagus  
 (orifice) lies noticeably beyond the apex of the strut and almost in a line with  
 it. Ovipositor short ..... 7
7. Abdominal segment incorporated in the terminalia, of the typical broad type.  
 Abdomen always with yellow hairs ..... *rufipes*-group ..... 16  
 Abdominal segment incorporated in terminalia, of the narrow type (unique to  
 group). Abdomen never with yellow hairs. .... *tibialis*-group. .... 19
8. Abdomen mainly yellow with a blue central area on dorsum. Ovipositor short as  
 far as known. .... PROECON. .... 9  
 Abdomen entirely blue, or rarely the last segment otherwise coloured ..... ? ONESIA
9. Frons on female much wider than long. Two presutural acrostichal bristles only.  
 ..... *augur*-group  
 Frons on female about as wide as long. Three presutural acrostichal bristles  
 present ..... *centralis*-group

## Subgenus ADICHOSIA.

10. Eyes on male almost contiguous. Thorax very densely covered with yellow, hiding  
 the ground-colour ..... *ochracea* Schiner  
 Eyes on male widely separated, almost as wide as on female. Thorax with a very  
 slight whitish covering not hiding the ground colour ..... *nigrithorax* Malloch

## Subgenus NEOPOLLENIA.

11. On the male the facets of the eyes are enlarged on the upper area and hence the eyes  
 are contiguous ..... 12  
 On the male the facets of the eyes are not enlarged above and hence the eyes are  
 conspicuously separated. Anterior clasper on male is exceptionally long at its  
 base, thus being about as long there as high ..... *australis* Boisduval
12. Anterior clasper normal at its base, being shorter than high .... *stygia* Fabricius  
 Anterior clasper long at its base, as in *australis*, being about as long there as its  
 height ..... *laemica* White
13. Abdomen with yellow hairs ..... 14  
 Abdomen without yellow hairs ..... *auriventris* Malloch
14. Strut of aedeagus, at centre, conspicuously bent forwards ..... *bessii* Hardy  
 Strut of aedeagus very slightly bowed forward uniformly and without a marked  
 bend ..... *canimicans* Hardy
15. Eyes of male separated by one-eighth the width of an eye. Legs slightly stained  
 with black ..... *deflexa* Hardy  
 Eyes of the male separated by one-seventh the width of an eye. Legs with the  
 coxae and femora entirely black ..... *sternalis* Malloch
16. Three presutural acrostichals present. Anterior coxae always yellow. Eyes of male  
 separated by the width of two ocelli ..... *fulvithorax* Hardy  
 Only two presutural acrostichals present. Anterior coxae dark ..... 17  
 Strut of aedeagus reaching only half-way towards the orifice ..... *milleri*, n. sp.  
 Strut of aedeagus reaching two-thirds the distance towards the orifice ..... 18
18. Eyes of the male separated by the width of two ocelli ..... *fallax* Hardy  
 Eyes of the male separated by the width of only one ocellus ..... *rufipes* Macquart
19. Femora entirely black, tibiae more or less reddish-brown. All pleural hairs black  
 ..... *tibialis* Macquart  
 Femora never entirely black, but brown and often more or less darkened over the  
 basal half or two-thirds. Some pleural hairs yellow ..... *perida*, n. sp.



*The synonymy of species in Neopollenia.*

Malloch referred to ten species of *Neopollenia* in his papers, and his distinguishing characters are so unsatisfactory that I do not find it easy to determine their exact identity. Below I give the evidence on which I have placed his forms. Some are yet to be checked on Malloch's original material, none of which has come before me.

*C. stygia*.—Malloch apparently had a complex under this name, judging on localities alone, for the species is unknown from New Zealand. The locality from which he illustrates the terminalia is not given, but probably this was somewhere in eastern Australia. His second reference gives "Swan River"; that, if adequately identified, must be *C. australis*. Only one specimen of *C. stygia* has been captured in Western Australia, and this is recognized as being an abnormal occurrence. Malloch's third reference is without specified locality.

*C. australis*.—The name is definitely rejected by Malloch on the view that it is either a synonym of *stygia* or else unrecognizable.

*C. fulvicoxa*.—The name is accepted by Malloch, who admits having it confused under *hilli*.

*C. rufipes*.—This name is referred to in two places on the same page, the remarks being ambiguous. First, he proposed dropping the name in favour of his interpretation of *hilli*, which he erroneously claimed to be a well-established species; then he says the species was originally described from Java, and referred it to *Hemilucilia*, believing it to be not Australian. There is reason to suppose he did not examine the description of *Pollenia rufipes* Macquart, 1835, which is the reference of the Australian species, the Javanese one being put into another genus by its author.

*Calliphora hilli* Patton (*nec* Malloch).—It is advisable to state here that there is no evidence to support the view that Malloch had seen this species and Malloch's references must be placed elsewhere.

*C. hilli* Malloch (*nec* Patton).—This was possibly based originally on *C. fallax*. and, as his material included three females from Eungella (Queensland), I was able to recognize that these, at least, were probably *C. fulvicoxa*, which later Malloch admitted. However, he rejected the view that the other specimens he had were *C. fallax*. I have seen no material from his locality "Barrington Tops". Malloch's further reference to *C. hilli* occurring in New Zealand is also at fault, and I have given this a new name below.

*C. auriventris* Malloch.—Known from a single female from the Fly River district. The description being inadequate for its recognition, the name stands in abeyance. There is known to me only one species that conforms to Malloch's description, and the specimens are from Tasmania, suggesting that I have not identified the species with any degree of assurance. My own references under the name belong to the Tasmanian species, and the determination is probably erroneous.

*C. sternalis* Malloch.—I believe I have placed this species successfully. The only character of importance that Malloch gives concerns the ventral plate of the terminalia, the apical sternite being conspicuously lobed, otherwise the species would have been quite unrecognizable.

*C. tibialis*.—Doubtless there is some misunderstanding in the determination of this well-recognized species, with which the original description does not agree. Brauer referred it to *Neopollenia*, evidently relying on Schiner's determination, but Malloch states that Schiner has two species of *villosa* standing under the

name amongst his material. I have been very loath to accept the name as more than a provisional one. Patton has compared specimens with the type, and it is generally recognized under the name in Patton's sense. However, I have isolated one form, giving it the name *perida*. This new form, apparently limited to Queensland, could hardly have reached Macquart, and so the name seems warranted.

*C. albifrontalis* Malloch, 1932.—Regarded by me as being quite unrecognizable from description, but Tillyard records it as a synonym of *australis* (Tillyard and Seddon, Council Sci. and Ind. Res., Pamphl. 37, 1933, p. 11, footnote). Patton claims that it is identical with *fulvicoxa* after examining the terminalia. Malloch only had two males of it and Patton does not say if one of these formed the determination of genital characters, or some other material. However, as Patton's view so readily coincides with the description, I believe it must be correct.

*C. varifrons* Malloch, 1932.—This is another species unrecognizable from the description. Patton states it is *rufipes*, but there was only one male in Malloch's material and the description reads like *australis* in many respects. There is a form corresponding to *rufipes* in Western Australia, but this does not agree with Malloch's description and perhaps Patton has this form confused owing to Malloch's comparisons with his *hilli*. The name *varifrons* can have no specific standing at present, and any further data should be based on Malloch's holotype specimen, for it is quite conceivable that he has a complex in his material. At present the name stands hardly more than a *nomen nudum*, and at best refers to *australis* with only two acrostichals, a not uncommon occurrence in the *stygia*-group.

#### CALLIPHORA STYGIA Fab.

*Musca stygia* Fab. 1781; Wiedemann 1832.—*Calliphora stygia* Schiner 1868; Hardy 1930; Patton 1935.—*Calliphora villosa* Desvoidy 1830.

A fly normal to the south-eastern quarter of the Commonwealth, mainly the coastal region, including Tasmania, but also the sheep country of New South Wales and Queensland, and Sydney and Brisbane. One specimen only is known from Western Australia. It is well known to be associated with myiasis, and occurs in its greatest density over the coastal region, including Adelaide and Melbourne.

#### CALLIPHORA AUSTRALIS Boisd.

*Musca australis* Boisdual 1835.—*Calliphora australis* Hardy 1930; Patton 1935.

Apparently this species is confined to Western Australia, where it is associated with myiasis.

#### CALLIPHORA LAEMICA White.

*Musca laemica* White, Dieffenbach's Travels in New Zealand, ii, 1843, 291. (All New Zealand references to *stygia* must be referred here.)

As far as yet known, this species is limited to New Zealand where it is associated with myiasis. I have other specimens, females only, from Norfolk Island which might possibly come here.

#### CALLIPHORA FULVICOXA Hardy.

*Calliphora fulvicoxa* Hardy 1930; Malloch 1932; Patton 1935.—*C. hilli* Malloch (nec Patton) in part, 1927.—*C. albifrontalis* Malloch 1932.

I have no personal knowledge of this occurring in Western Australia, but Patton recognized it in a form that he regards, probably quite correctly, as *albifrontalis*. It is common in the vicinity of Brisbane and Adelaide, showing it to be possibly a north-western species in contrast with the range of *C. rufipes*, the two meeting in Adelaide.

Little is known concerning the economy of this fly, but during experiments conducted by Miss Joan Cue, at the Queensland University, it was found to oviposit on carrion that had been retained several days, whereas *C. fallax* only oviposited in fresh carrion. It is unlikely that this fly will be found associated with myiasis, as it is not normally reared from carrion and does not seem to be attracted to traps.

CALLIPHORA FALLAX Hardy.

*Calliphora hilli* Malloch (nec Patton), in part, 1927; and in toto, 1932.—*Calliphora fallax* Hardy 1930; Patton 1935.

This fly is only known definitely from Queensland and New South Wales, being mainly a coastal fly, but found also in the sheep country in both States, where it is associated with myiasis.

CALLIPHORA RUFIPES Macquart.

*Pollenia rufipes* Macquart 1835.—*Calliphora rufipes* Hardy 1930; Patton 1935.—*Calliphora hilli* Patton 1927 (nec Malloch).

The type localities given under the two original descriptions are practically identical, a few miles only separating the recorded places, and I have material before me from both. It is the common blowfly of that neighbourhood. Specimens are before me from Tasmania, Victoria and South Australia, but from no other State. Probably this species is capable of association with myiasis, but the records standing under the name *hilli* are likely to refer to *fallax*, on the mainland of Australia, for the present fly seems strictly limited to the coastal region and is likely to be found in the interior only as an occasional migrant.

CALLIPHORA MILLERI, n. sp.

*Calliphora hilli* Malloch (nec Patton), in part only, 1927.

This is the common blowfly of New Zealand that goes under the name *hilli*, and I am indebted to Dr. D. Miller for specimens. I also have seen his drawings of terminalia which show quite distinctive features, the most noticeable being a superabundance of bristles on the claspers, the more gently curved strut and the much longer part lying beyond that relative to its two allies in Australia. It is also distinguishable by the eyes being placed apart slightly in excess of that found on *rufipes*. It is only known from New Zealand, where it is associated with the myiasis of sheep.

CALLIPHORA PERIDA, n. sp.

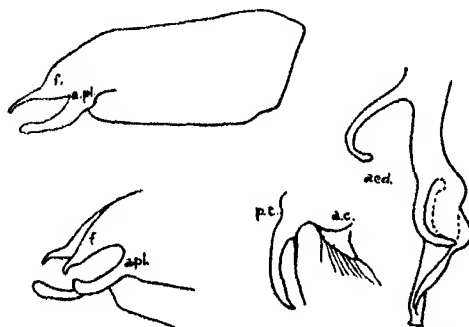
Closely related to *C. tibialis*, from which it may be distinguished by its brown femora, typically brown but often more or less darkened from the base to about half to two-thirds the length, being very variable in this respect. The only other feature of difference that has been noted is in the pleura and anterior coxae, both, or either, having yellow hairs, the number varying. No difference has been found in the terminalia or in the width between the very closely set eyes.

This fly is only known to me from Queensland, being quite plentiful around Brisbane, and occurs throughout the year, being associated during much of the winter and spring periods with the typical *C. tibialis*. However, between these two flies there is also a marked difference in habit, *perida* sporting on bushes whereas *tibialis* is strictly confined to the ground. Through all the years that I have been collecting and watching this fly and observing its habits, I have not found any actual joining up of the two distinguishing characters. When the

yellow pleural hairs are present, the femora are invariably brown in the main, whereas when no yellow hairs are to be seen, no brown is noted on the femora.

*Hab.*—Queensland. Brisbane; about 100 specimens are selected for the type series. Goondiwindi, 1 male.

Southern forms of the *tibialis* group also need close investigation, for I have specimens strongly suggesting that a complex occurs around Adelaide, and this



*Calliphora perida*, n. sp.—aed., aedeagus; a.c., anterior clasper; p.c., posterior clasper; f., forceps; a.pl., accessory plate. Note the long narrow shape of the apical tergite; the lower figure shows the parts as seen on a mount, the forceps being broader than appears in the lateral view, when unmounted.

possibly new species may be extending towards Melbourne. I judge this from a long series taken in the two States concerned. From Sydney and from Tasmania I have seen only the typical form without marked variations.

#### CALLIPHORA AUGUR Fab.

*Musca augur* Fabricius 1775.—*Calliphora augur* Patton 1925, 1935; Hardy 1926, 1930; Malloch 1927 in part, and 1928 in part.

The synonymy that stands tentatively under this species is rather extensive and it is possible the names do not all belong to the one species. On the published evidence it is not possible to attach the names to any other species known to me.

The present species occurs in Tasmania, Victoria and perhaps in certain mountain areas of New South Wales as a permanent resident; it is also found in the southern coastal regions of Queensland and in the sheep country of the two latter States as a seasonal fly only. The limit of its western occurrence is not known. It is associated with myiasis.

#### CALLIPHORA NOCIVA Hardy.

*Calliphora augur* Malloch 1927 and 1928 in part only, and many references in literature.—*Calliphora nociva* Hardy 1932; Patton 1935.

The permanent limits of this fly do not seem to extend eastward far beyond South Australia along the coastal region, but it is found in Melbourne and in Canberra. Its northern range includes Central Queensland, but apparently it does not enter the coastal region of this State, nor yet of New South Wales. It is associated with myiasis. Possibly the fly is typical of the Mallee areas.

## CALLIPHORA CENTRALIS Malloch.

*Calliphora centralis* Malloch, 1927; Hardy 1932; Patton 1935.

The range of this species is wide enough to suggest that an earlier name may be found for it. It apparently occurs through the coastal region of New South Wales, north of Sydney and far up into the Queensland coastal section. Normally it is confined to timbered country of the plains and low hills, and appears also to be a permanent resident in timbered districts of the western plains of Queensland, 300 miles inland at least. It is not attracted by carrion, nor yet caught in traps, as far as my experience goes.

## CALLIPHORA FUSCOFEMORATA Malloch.

*Calliphora fuscifemorata* Malloch 1927.

I have a male of this species taken from very near the type locality (caught by Miss V. Irwin-Smith) and have examined its terminalia. It would appear to be a good species that cannot be confused with any earlier description. The form is only known from the northern parts of Queensland, probably confined to the rain-forest areas, just as *C. falciformis* Hardy may prove to be in the more southern rain-forest areas. Judging from its terminalia, Patton was quite correct in placing it with the *canimicans*-group in order to be consistent in his scheme of classification. In accordance with my key to species under genus *Proekon*, it goes into a new group characterized not only by the terminalia, but also in having two presutural acrostichal bristles and the blue metallic margin at apex of abdominal segments, but I list it for the time being in the *centralis*-complex; it does not agree with the definition of the group in the key given above.

*Distribution.*

The subgenus *Adichosia* is apparently limited to eastern Australia, and is represented by only two forms.

*Neopollentia* occurs in North Queensland, Norfolk Island, New Zealand, Tasmania, and Western Australia, which seem to mark the limits of distribution. South-eastern Australia and Tasmania are the areas of its greatest abundance.

*Proekon* is known from New Caledonia, Australia, Tasmania, and is recorded from Timor; it may even occur in New Guinea. Queensland is the area of its greatest abundance.

The coastal region of Australia, for the purpose of this account, may be divided into four quadrants, north-west, south-west, north-east and south-east.

The north-western quadrant is practically an unknown region in regard to Calliphoras as no systematic collecting has been done there. As seen below, it may possibly prove to be the centre of distribution for *C. fulvicoxa*. The south-western quadrant has been under investigation during recent years. The eastern side of Australia has been well covered and is best known.

The data given in this paper suggest that each quadrant has its own particular fauna in permanent residence, but is invaded periodically from some other region by species that are unable to become permanently established.

## ADICHOSIA.

This subgenus contains only two known species and is probably the most primitive of the Calliphoras. One species, *ochracea*, breeds throughout the year in the rain-forests within the north-eastern quadrant, and the other, *nigrithorax*, in similar conditions in the south-eastern quadrant. Elsewhere it appears to be a seasonal fly only.

## NEOPOLLENIA.

The south-eastern quadrant has in permanent residence, *stygia*, *rufipes* and *tibialis*, three of the four first-described species. In addition, this is the only area in which *bezzii* and *deflexa* are known, and there are other species (Tasmanian) yet to be described. The north-eastern quadrant has *canimicans*, *sternalis*, *fallax* and *perida*. The south-western quadrant has *australis* and a species near *rufipes*. The north-western quadrant may possibly be the centre of the widely distributed *fulvicoxa*, for this is unknown from the south-eastern quadrant except at Adelaide, but is recorded from Perth and was described from Brisbane. But it might similarly be regarded as a Central Australian species which reaches the coast at the places mentioned.

## PROCKON.

This subgenus has one species each in the south-western and the south-eastern quadrants, namely, *noctua* and *augur* respectively. The former extends its permanent range eastward to the border country of Victoria. All the other species known are practically limited to the north-eastern quadrant.

The two southern species may be breeding in different types of country, for *noctua* seems to favour the mallee areas, whereas *augur* occurs in the other wooded districts, the two meeting in the open plains.

Those species listed in the *centralis*-group and which are apparently restricted to the one quadrant, seem to show a tendency to definite regional distribution within that quadrant. The majority described and undescribed may be northern flies, but *centralis* seems to be typical of the open forest and *falciformis* of the rain forests, both occurring in the southern section of the quadrant.

## PHYLOGENY.

Patton gives some phylogenetic ideas on the development of the terminalia, which seem to be quite sound in principle but reversed in direction of presumed development. Taking into account characters other than terminalia, it would seem that *Adichsia nigrithorax* would be the most primitive *Calliphora* extant, for it has hairy dichoptic eyes. The other species in the subgenus, also with hairy eyes, has the holoptic form; this also is the form towards which the other two subgenera trend. It seems to me probable that the terminalia of *Adichsia* may also be of the primitive type and should be placed at the base of the Calliphorine stem.

Patton, however, believes that the form of terminalia found on *augur* (*Prockon*) is the primitive one, and if this be the case we would have the curious incident of a primitive group being the one most abundant in species and the most advanced forms in the numerical minority. Also, the advanced form would have a restricted distribution, the primitive form a wide one.

Making the necessary adjustment, and accepting Patton's main theme, a diagram of phylogeny may be built up, as shown in the adjacent arrangement. I offer this diagram as a tentative one, but from data I have gathered by the study of other genera of the Calliphoridae, I think the general trend of the subject will be maintained. It may be shown that the ovipositor was originally long, and the strut developed from an independent thin support to become thickened and fused with other parts of the aedeagus later, the form taken in *canimicans* being an intermediate stage.

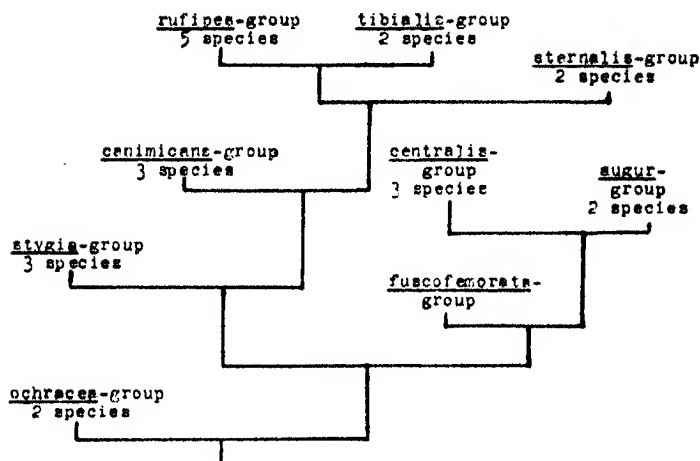


Diagram of Phylogeny.

Patton places the *sternalis*-group as associated with the *canimicans*-group for a reason unknown to me.

*Key to the Phylogenetical Considerations.*

1. Eyes hairy, primitively dichoptic at least in part. Strut free and slender. Ovipositor long ..... *ochracea*-group  
Eyes bare, the dichoptic nature strongly tends to disappear ..... 2
2. Strut still free and slender and the ovipositor long ..... *stygia*-group  
Strut bound to other parts of aedeagus by membrane throughout its length. Ovipositor probably short in all cases or perhaps in some strongly tending that way ..... 3
3. Strut still slender ..... *canimicans*-group; *fuscofemorata*-group  
Strut broadened ..... 4
4. Strut normally broadened but curved at least at its apex; other characters of terminalia normal in general form ..... 5  
Strut abnormally broad and straight, only reduced at apex to a point not showing a marked trend forwards. Other parts of terminalia showing abnormal development at least in part, especially so in the development of secondary plates ..... *sternalis*-group
5. Ninth tergite normal in breadth ..... *rufipes*-group  
Ninth tergite elongate relative to its breadth being markedly longer than broad ..... *tibialis*-group

It will be noted that I use the name *fuscofemorata* for a group and place it in the above key and diagram. I do not expect the name to remain permanently, for the subgenus *Proekon* is not yet well understood. The *centralis*-group and the *augur*-group fall into alignment with the *rufipes*-group and there are none known to me within the subgenus *Proekon* that are comparable with the *tibialis*-group and the *sternalis*-group.

The subgenus *Onesia* stands in relation to *Neopollenia* very much as *Proekon* does, only it has more numerous species, some of which, like *fuscofemorata*, fall into alignment with the *canimicans*-group and some with the *ruficeps*-group. The introduced *erythrocephala*-group is in alignment with the *stygia*-group.

*References.*

- PATTON.—Ann. Trop. Med. and Parasit., Liverpool, xxix, 1935, 19-32.  
HARDY.—Bull. Ent. Res. London, xxi, 1930, 441-8; and xxiii, 1932, 549-558.  
MALLOCH.—PROC. LINN. SOC. N.S.W., III, 1927, 299-335; III, 1928, 598-617; and IV, 1932, 64-8.

## A CENSUS OF THE ORCHIDS OF NEW SOUTH WALES, 1937.

By the REV. H. M. R. RUPP, B.A.

[Read 28th April, 1937.]

The Census of New South Wales Plants, by J. H. Maiden and Ernest Betche (1916), recorded 177 species of Orchids—an increase of only four since the publication of Moore and Betche's "Handbook of the Flora of N.S.W." in 1893. Recent research has indicated that of these 177, at least four should be deleted from the list. Mr. W. H. Nicholls has demonstrated (*Vict. Nat.*, June, 1936) that no authentic Australian specimens of *Thelymitra longifolia* Forst. can be discovered, and it seems that this species is restricted to New Zealand. Mr. Nicholls has also shown (*Vict. Nat.*, June, 1934) that Fitzgerald's *T. megalyptra* is really conspecific with Lindley's *T. aristata*. Fitzgerald's *Pterostylis striata* is now generally admitted to be *P. alata* Reichb. f.; and the present writer is convinced that *P. cucullata* R.Br. has not yet been recorded in New South Wales. Brown's name has been mistakenly bestowed upon a very different species, *P. falcata* Rogers. Some doubt exists in regard to a number of other species. No one has seen *Diuris dendrobioides* Fitzg., or *Pterostylis clavigera* Fitzg., for over forty years, and as no specimens are available, their validity cannot be tested. Several of the same author's *Prasophyllum* species are also quite unknown to the present generation, as also is his *Anticheirostylis apostasioides*. But of course these may yet be re-discovered, and they should therefore be retained on the list. The possibility of re-discovery is indicated in the fact that since Maiden and Betche's Census was published 45 species and one new genus have been added to the Orchid flora of the State.

Alterations in nomenclature, due either to the application of the international priority rule, the transference of species, or the deletion of genera, have become necessary since the 1916 Census. Two of these—*Dendrobium elongatum* Cunn., instead of *D. gracilicaule* F.v.M., and *Bulbophyllum crassulaefolium* Cunn., instead of *B. Shepherdii* F.v.M., are here published for the first time, on the authority of Dr. R. S. Rogers of Adelaide. In both instances Cunningham's description preceded Mueller's by many years. Dr. Rogers thinks Mueller may have suppressed *D. elongatum* to avoid confusion with a non-Australian plant of Lindley's; but the latter's *D. elongatum* is merely a synonym for his *D. cymbidioides*, and has no standing. With regard to *Bulbophyllum crassulaefolium*, Dr. Rogers writes: "Cunningham did not see the plant in flower, and apparently thought it might prove to be a *Dendrobium*. His coloured drawing of it is preserved at Kew Gardens; the habit of the plant agrees perfectly with Mueller's *B. Shepherdii*, and the locality (Blue Mountains) is identical." This little *Bulbophyllum* is very common in many parts of the State.

Deleting the four species cited above from Maiden and Betche's Census, and adding 45 to the remaining 173, we now have 218 Orchids on record for this State. In the Census list below I have only given references to descriptions, etc., in the



case of those which are not listed in the 1916 Census. In all other cases Maiden and Betches's work should be consulted. I have used the following abbreviations:

*Fragm.*—Mueller's *Fragmenta Phytographiae Australiae*.

*Q. Fl.*—F. M. Bailey's *Queensland Flora* (1902).

*S.A. Orch.*—Dr. R. S. Rogers' *South Australian Orchids*.

*Orch. N.S.W.*—Rupp's *Guide to the Orchids of N.S.W.*

*Bot. Reg.*—Curtis's *Botanical Register* (London).

\* Denotes plants recorded since the 1916 Census.

† Denotes an alteration in nomenclature.

#### LIPARIS Rich.

*reflexa* Lindl.

*coslogynoides* F.v.M.

\**habenaria* F.v.M., *Fragm.*, iv, 131.  
See *Vict. Nat.*, May, 1935.

\**Simmondsii* Bail., *Q. Fl.*, p. 1521, also  
*Botany Bulletin*, Q'land. Dept. of  
Agriculture, xix, 1917, p. 12 (J. F.  
Bailey and C. T. White); see also  
*Aust. Orch. Review*, March, 1937.

#### OBORONIA Lindl.

*iridifolia* Lindl.

*Titania* Lindl.

#### DENDROBIUM Swz.

*speciosum* Sm.

var. *Hilli* F.v.M.

\*var. *gracillimum* Rupp, *PROC. LINN.*  
*Soc. N.S.W.*, lix, 5, 1929.

\**Kestevenii* Rupp, *PROC. LINN. Soc.*  
*N.S.W.*, lvi, 2, 1931; *Q. Nat.*, March,  
1935.

*falcorostrum* Fitzg.

*tetragonum* Cunn.

*aemulum* R.Br.

*Kingianum* Bidw.

\*var. *Silcockii* Bail., *Q. Fl.*, p. 1528.

†*elongatum* Cunn., *Bot. Reg.*, 1839.  
(*D. gracilicaule* F.v.M., see above.)

*monophyllum* F.v.M.

\**Schneiderae* Bail., *Q. Fl.*, p. 1531.

*cucumerinum* Macleay.

*pugioniforme* Cunn.

*linguliforme* Swz.

*teretifolium* R.Br. See *PROC. LINN.*  
*Soc. N.S.W.*, lx, 3-4, 1935.

var. *Fairfaxii* Fitzg. and F.v.M.

*striolatum* Reichb. f.

*Beckleri* F.v.M.

\**tenuissimum* Rupp, *PROC. LINN. Soc.*  
*N.S.W.*, lli, 4, 1927.

*Mortii* F.v.M.

#### BULBOPHYLLUM Thou.

†*crassulaefolium* Cunn., *Bot. Reg.*, 1839,  
*Misc.*, p. 33. (*B. Shepherdii* F.v.M.  
See above.)

†*bracteatum* Bail. (*Adelopetalum bracteatum* Fitzg. See *Q. Fl.*, p. 1539.  
It is generally recognized now that  
Bailey's treatment of this Orchid  
is correct.)

*aurantiacum* F.v.M.

*exiguum* F.v.M.

*minutissimum* F.v.M.

*Eliae* F.v.M.

\**Weinthalii* Rogers, *Trans. Roy. Soc.*  
*S. Austr.*, lvii, 1933.

#### TARNIOPHYLLUM Blume.

*Muelleri* Lindl.

#### SARCOCHILUS R.Br.

*divitiflorus* F.v.M.

*falcatus* R.Br.

var. *montanus* Fitzg.

\**Weinthalii* Bail., *Q'land Agricultural*  
*Journal*, xlii (1903), 346, and  
xxviii, Part 6 (June, 1912), 448.

\**Hartmannii* F.v.M. *Fragm.*, viii, 248.  
See Abstract *PROC. LINN. Soc.*  
*N.S.W.*, No. 482, Aug., 1935.

*Fitzgeraldii* F.v.M.

*olivaceus* Lindl.

\**spathulatus* Rogers, *Trans. Roy. Soc.*  
*S. Austr.*, li, 1927.

\**dilatatus* F.v.M., *Fragm.*, i, 191. See  
also Rogers, loc. cit.

*parviflorus* Lindl.

*Ceciliae* F.v.M.

*Hilli* F.v.M.

*erichthius* Fitzg.

#### CLEROSTOMA Blume.

*tridentatum* Lindl.

*Beckleri* F.v.M.

#### ORNITHOCHILUS Wall.

*Hilli* Benth.

#### GEODORUM Jacks.

*pictum* Lindl.

#### DIPODIUM R.Br.

*punctatum* R.Br.

\**Hamiltonianum* (Bail.) Cheel, *PROC.*  
*LINN. Soc. N.S.W.*, lvii, 1-2, 1923.

#### CYMBIDIUM Swz.

*canaliculatum* R.Br.

\**forma aureolum* Rupp, *PROC. LINN.*  
*Soc. N.S.W.*, lix, 1-2, 1934.

\**iridifolium* Cunn., *Bot. Reg.*, 1839,  
*Misc.* 34. (*C. albuciflorum* F.v.M.  
See Rupp, loc. cit.)

*suave* R.Br.

#### PHAIUS Lour.

*grandifolius* Lour. (Now almost extinct  
in N.S.W.)

#### CALANTHE R.Br.

*veratrifolia* R.Br.

#### GALEOLA Lour.

*cassythoides* Reichb. f.

*Ledgeriana* F.v.M.

- EPIPOGUM* Gmel.  
*mutans* Lindl.  
*GASTRODIA* R.Br.  
*sesamoides* R.Br.  
*\*CRYPTANTHEMIN* Rupp, PROC. LINN. SOC. N.S.W., lvi, 1-2, 1932.  
*\*Slateri* Rupp, loc. cit. and lxx, 3-4, 1934.  
*CHEIROSTYLIS* Blume.  
*grandiflora* Blume.  
*SPIRANTHES* Rich.  
*sinensis* (Pers.) Ames. (*S. australis* Lindl.)  
*CALOCYLUS* R.Br.  
*campestris* R.Br. (Doubt has been expressed in regard to this species. It is certain that in N.S.W. it was long confused with the species now known as *C. cupreus* Rogers. But Brown recorded it both in N.S.W. and Queensland. I believe it is much less common than was formerly supposed; but I have collected it near Bullahdelah, and have seen specimens from various districts.)  
*\*grandiflorus* Rupp, Vict. Nat., Feb., 1934, and Abstract, PROC. LINN. SOC. N.S.W., Aug., 1935.  
*\*cupreus* Rogers, Trans. Roy. Soc. S. Austr., xlii, 1918.  
*Robertsonii* Benth.  
*pallidus* R.Br.  
*THELYMITRA* Forst.  
*isotides* Swz.  
*media* R.Br.  
*circumscripta* Fitzg.  
*aristata* Lindl. (For the inclusion of Fitzg.'s *T. megacalyptra* in this species see Nicholls, Vict. Nat., Oct., 1934, and for the association of *T. aristata* and *Dendrobium Kingianum*, see Rupp, Vict. Nat., Nov., 1934.)  
*\*pauciflora*, R.Br., *Prodromus*, p. 314.  
*nuda* R.Br.  
*\*chasmogama* Rogers, Trans. Roy. Soc. S. Austr., li, 1927. See also PROC. LINN. SOC. N.S.W., ix, 3-4, 1935.  
*carnea* R.Br.  
*Elizabethae* F.v.M. See Rogers, Trans. Roy. Soc. S. Austr., li, 1927.  
*venosa* R.Br.  
*DIURIS* Sm.  
*alba* R.Br.  
*punctata* Sm. (*D. elongata* R.Br.)  
*cuneata* Fitzg.  
*spatulata* Fitzg.  
*\*venosa* Rupp, PROC. LINN. SOC. N.S.W., li, 3, 1926, and llii, 4, 1928.  
*dendrobioideae* Fitzg.  
*secundiflora* Fitzg.  
*tricolor* Fitzg.  
*Sheaffiana* Fitzg.  
*maculata* Sm.  
*aequalis* F.v.M.  
*bracteata* Fitzg.  
*platichilus* Fitzg.  
*aurea* Sm.  
*\*palachila* Rogers, S. Austr. Orchids, p. 33.  
*\*brevifolia* Rogers, Trans. Roy. Soc. S. Austr., xlii, 1922.  
*sulphurea* R.Br.  
*abbreviata* F.v.M.  
*pedunculata* R.Br.  
*pollens* Benth.  
*ORTHOCEPHALUS* R.Br.  
*striatum* R.Br.  
*CRYPTOSTYLIS* R.Br.  
*†subulata* Reichb. f. (*C. longifolia* R.Br.)  
*erecta* R.Br.  
*leptochila* F.v.M.  
*PRASOPHYLLUM* R.Br.  
*australe* R.Br.  
*flavum* R.Br.  
*elatum* R.Br.  
*brevilabre* Hook.  
*patens* R.Br.  
*\*Rogersii* Rupp, PROC. LINN. SOC. N.S.W., lli, 4, 1928.  
*\*odoratum* Rogers, S. Austr. Orch., p. 15.  
*\*gracile* Rogers, loc. cit., p. 14.  
*\*Frenchii* F.v.M. See Pescott, Orchids of Victoria, p. 31.  
*\*Suttonii* Rogers and Rees. See Vict. Nat., July, 1933; but the Barrington Tops record there given is a mistake.  
*fuscum* R.Br. (Mr. W. H. Nicholls has recently reviewed this species and found it to include more than one. But his treatment of the group has not yet been applied to the N.S.W. forms. Malden and Bêche recognized vars. *alpinum* and *grandiflorum*, but for the present it may be better to include all forms under the specific name.)  
*striatum* R.Br.  
*Baueri* Poir.  
*Deaneapum* Fitzg.  
*longicaepalum* Fitzg.  
*nigricans* R.Br.  
*transversum* Fitzg.  
*ansatum* Fitzg.  
*laminatum* Fitzg.  
*rufum* R.Br.  
*densum* Fitzg.  
*viride* Fitzg.  
*filiforme* Fitzg.  
*†Archeri* Hook. (*P. intricatum* Stuart. See Nicholls, Vict. Nat., Oct., 1931.)  
*\*Morrisii* Nicholls, loc. cit.  
*\*Hopsonii* Rupp, PROC. LINN. SOC. N.S.W., llii, 4, 1928.  
*Woollettii* F.v.M.

- reflexum* Fitzg.  
*eriochilum* Fitzg.  
*ambriatum* R.Br.  
*\*acuminatum* Rogers, *Trans. Roy. Soc. S. Austr.*, li, 1927. See also *Orch. N.S.W.*, p. 87.  
*\*Ruppit* Rogers, loc. cit.; also *Orch. N.S.W.*, p. 88.  
*\*Nublingii* Rogers, loc. cit.; also *Orch. N.S.W.*, p. 89.  
 ANTICHEIROSTYLIS Fitzg.  
*apostasioides* Fitzg.  
 MICROTIS R.Br.  
*\*magnadenia* Rogers, *Trans. Roy. Soc. S. Austr.*, liv, 1930.  
*porrifolia* Spreng.  
*parviflora* R.Br.  
*\*oblonga* Rogers, *Trans. Roy. Soc. S. Austr.*, xlvii, 1923.  
 CORYSANTHES R.Br.  
*pruinosa* Cunn.  
*ambriata* R.Br.  
*\*diemenica* Lindl. (See *PROC. LINN. SOC. N.S.W.*, liii, 2, 1928, p. 81.)  
*\*undulata* Cunn. (See Rogers, *Trans. Roy. Soc. S. Austr.*, li, 1927, also refer to *PROC. LINN. SOC. N.S.W.*, loc. cit., p. 88.)  
*bicalcarata* R.Br.  
*unguiculata* R.Br.  
 PTEROSTYLIS R.Br.  
*ophioglossa* R.Br.  
*\*var. collina* Rupp, *PROC. LINN. SOC. N.S.W.*, liv, 5, 1929.  
*concinna* R.Br.  
*acuminata* R.Br.  
*Baptistii* Fitzg.  
*curta* R.Br.  
*nutans* R.Br.  
*var. hispidula* Fitzg.  
*clavigera* Fitzg.  
*nana* R.Br.  
*pedoglossa* Fitzg.  
*pedunculata* R.Br.  
*\*furellata* Rupp, *PROC. LINN. SOC. N.S.W.*, lv, 4, 1930.  
*\*furcata* Lindl. (See Rogers, *Trans. Roy. Soc. Vict.*, xxviii [new series], 1, 195.)  
*\*alpina* Rogers, loc. cit.  
*\*falcata* Rogers, loc. cit.  
*\*pulchella* Messmer, *PROC. LINN. SOC. N.S.W.*, lviii, 5-6, 1933.  
*grandiflora* R.Br.  
*truncata* Fitzg.  
*reflexa* R.Br.  
*\*revoluta* R.Br. (See *PROC. LINN. SOC. N.S.W.*, liii, 5, 1928, p. 553.)  
*coccinea* Fitzg.  
*†alata* Reichb. f. (*P. praecox* Lindl., *P. striata* Fitzg.)  
*obtusata* R.Br.  
*parviflora* R.Br. (Maiden and Betcher record var. *aphylla* Ewart and White. *P. parviflora* is so variable a species, and, in N.S.W. at least, the appearance of leaves is often so much later than the flowers, that the validity of var. *aphylla* seems doubtful in this State.)  
*mutica* R.Br.  
*cycnocephala* Fitzg.  
*rufa* R.Br. (The group of which this species is representative calls for review, as there is considerable confusion of forms.)  
*\*pusilla* Rogers, *Trans. Roy. Soc. S. Austr.*, xlii, 1918.  
*\*var. prominens* Rupp, *PROC. LINN. SOC. N.S.W.*, lvi, 2, 1931.  
*†Mitchellii* Lindl. (*P. rufa* var. *Mitchellii*.)  
*†squamata* R.Br. (*P. rufa* var. *squamata*.)  
*Woollii* Fitzg.  
*Daintreyana* F.v.M.  
*longifolia* R.Br.  
*barbata* Lindl.  
 CALADENIA R.Br.  
*major* R.Br.  
*minor* R.Br.  
*\*Nublingii* Nicholls, *Vict. Nat.*, May, 1931.  
*†SPICULAEA* Lindl. (*Drakaea* Lindl.)  
*irritabilis* Reichb. f.  
*Huntiana* F.v.M.  
 ACIANTHUS R.Br.  
*caudatus* R.Br.  
*fornicatus* R.Br.  
*exsertus* R.Br.  
*tremiformis* R.Br. (*Cyrtostylis rentiformis* R.Br.)  
 ERIOCHILUS R.Br.  
*†cucullatus* Reichb. f. (*E. autumnalis* R.Br.)  
 LYPERANTHUS R.Br.  
*ellipticus* R.Br.  
*suaveolens* R.Br.  
*nigricans* R.Br.  
*†BURNETTII* Lindl. (*Lyperanthus*, partly.)  
*†cuneata* Lindl. (*L. Burnettii* F.v.M.)  
 CHILOGLOTTIS R.Br.  
*†reflexa* (Lab.) Cheel. (*C. diphylla* R.Br.)  
*trapeziformis* Fitzg.  
*formicifera* Fitzg.  
*trilabra* Fitzg.  
*Gunnii* Lindl.  
 ADENOCHILUS Hook.  
*Nortonii* Fitzg.  
 CALADENIA R.Br.  
*filamentosa* R.Br.  
*Patersonii* R.Br.  
*dilatata* R.Br.  
*\*var. concinna* Rupp, *PROC. LINN. SOC. N.S.W.*, liii, 5, 1928.  
*arenaria* Fitzg.  
*concolor* Fitzg.

- clavigera* Cunn.  
*tesselata* Fitzg.  
 \**angustata* Lindl. (See Rupp, Proc.  
 Linn. Soc. N.S.W., lvi, 5, 1931.)  
 \**alpina* Rogers, Trans. Roy. Soc. S.  
 Austr., li, 1927.  
*cucullata* Fitzg.  
*testacea* R.Br.  
*carnea* R.Br.  
 \*var. *gigantea* Rogers, Trans. Roy.  
 Soc. S. Austr., li, 1927.
- alba* R.Br.  
*latifolia* R.Br.  
*dimorpha* Fitzg.  
*congesta* R.Br.  
 \**tutelata* Rogers, S.A. Orch., p. 30.  
*caerulea* R.Br.  
*deformis* R.Br.  
 GLOSSODIA R.Br.  
*major* R.Br.  
*minor* R.Br.
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## AUSTRALIAN HESPERIIDAE. VI.

## DESCRIPTIONS OF NEW SUBSPECIES.

By G. A. WATERHOUSE, D.Sc., B.E., F.R.E.S.

[Read 28th April, 1937.]

During part of 1936 I spent some time at the British Museum of Natural History in consultation with Brigadier W. H. Evans, who has been making a study of the species of this family for the whole world. The following new races are the result of part of my investigations in England. The types are all in the Australian Museum. The next part will contain my notes on the Australian types and their localities.

## TRAPEZITES PHIGALIA Hewitson.

*Hesperia phigalia* Hew., 1868, Descriptions of 100 new species of Hesperidae, p. 32.

Hewitson described this species from his own collection, giving as locality simply "Australia". Kirby's List of the Hewitson Collection mentions two specimens, but I was only able to find one, which was labelled by F. A. Heron, *Hesperilla phigalia* No. 2. This was a female and has been considered the holotype. It does not quite conform to the description, as it has a very small spot in area 1a immediately below the large spot in 2, on the upperside of the forewing, also the underside of the hindwing is not grey, but yellowish-brown. The size given by Hewitson is slightly smaller than for his *T. eliena* and slightly larger than for his *T. petalia*, both described on the same page as *T. phigalia*. This suggests that Hewitson was describing a male. I find it difficult to assign a type locality for the specimen in the British Museum as the underside of this specimen does not agree with any of the long series I have from South Queensland, New South Wales, Victoria and South Australia. As there is evidence that Hewitson did not obtain any of his material from New South Wales or Victoria, and the description does not apply to the South Queensland race, I can only assign the type locality as near Adelaide. There was a Hewitson specimen of *T. petalia* which bore a label *Hesperilla phigalia* No. 1. The holotype of *T. petalia* is labelled No. 2, Kirby listing two specimens of this species in the Hewitson collection, both of which I found.

## TRAPEZITES PHIGALIA PHILA, n. subsp.

The chief difference in this race is the decidedly pink tint on the apex of the forewing and the hindwing on the underside. In addition, the broad orange band on the upperside of the hindwing is divided by darker veins, in both sexes. These characters are only found in specimens from South Queensland. The holotype male from Stradbroke Is., caught in September, has the ring spots on the underside of the hindwing more indistinct than three other males from the same locality. There are also one male and two females from Noosa, Qld., also caught in September, but the pink on the underside is not quite so marked as in the Stradbroke specimens. They are, however, not grey as in specimens from southern localities.

## MOTASINGHA ATRALBA Tepper.

*Hesperilla atralba* Tepper, *Trans. Roy. Soc. S. Aust.*, iv, 1880-1, p. 33, Pl. 2, fig. 5.

The holotype is a female in the South Australian Museum from Ardrossan, Yorke's Peninsula, S. Aust., and now consists of two wings only. The male of the typical race has an inconspicuous stigma, very different from the broad stigma in males of the Western Australian races. Brigadier Evans has examined the genitalia, but so far finds nothing to warrant separating the races as distinct species. The race *atralba* has the spots whiter than the other races. It has two broods, but most specimens have been caught in April. I have examined the series of *dactyliota* Meyrick, 1888, in his collection. They consisted of two males and a female from Geraldton, W.A., and a female from Port Lincoln, S. Aust.; the latter belongs to typical *atralba*. Mr. Meyrick has presented one of his males to the Australian Museum, and it is now before me. They are smaller than typical *atralba* and, now I have seen this series, I find that those specimens from further south in Western Australia, to which I applied the name *dactyliota*, are distinct races. The race *nila* Waterhouse, 1932, from Dirk Hartog Is., W.A., in August, is the same size as *dactyliota*, the spots on the forewing above are slightly smaller and the hindwing beneath is yellowish-brown, unlike any of the other races.

## MOTASINGHA ATRALBA ANACES, n. subsp.

*M. atralba dactyliota*, Waterhouse and Lyell, 1914, p. 196, figs. 648, 773; Waterhouse, 1932, "What Butterfly is That?", p. 234, Pl. xxx, fig. 18.

This is the largest race yet known; on the upperside the spots on the forewing in the male are proportionately smaller and there is rarely a spot in 2; the blotches on the hindwing are more extensive and greenish-grey. On the underside the apex of the forewing and the hindwing have a pinkish tint and there are usually two spots in 1a on the forewing; the spots on the hindwing are less defined than in the other Western Australian races. In the female the spots on the upperside are nearly as large as in the typical race.

Described from four males and one female from Hamel (R. Illidge) and five males from Waroona (G. F. Berthoud), all caught from 15th to 30th Oct., 1918. These localities are close together and somewhat south of Perth, W.A.

## MOTASINGHA ATRALBA ANAPUS, n. subsp.

This race is the same size as *dactyliota* and *nila*. On the upperside the spots of the forewing are smaller than in *dactyliota* and that in 3 is round, those in 4 and 5 small and placed directly under one another. On the underside the apex of forewing is grey and in 1a there is an additional spot, the hindwing is grey and the spots are much more distinct than those of *anaces*. The holotype is a male from Stirling Ranges, W.A., caught in October with three other males in poor condition. One of these has the spots in 4 and 5 of the forewing much larger than in any male I have seen from Western Australia.

## SUNIANA LASCIVIA LASUS, n. subsp.

This is a very small northern race, the forewing in the male being less than 9 mm. and in the female less than 10 mm. The markings above are bright orange and well defined, especially that along the lower margin and end of cell, the band of the hindwing is proportionately broader than in *lascivia* from the south. On the underside of the forewing, the cell is broadly orange, the three subapical spots and the discal band are well marked, as is also the band on the hindwing. This race is easily distinguished from typical *lascivia* from New South Wales and

Victoria by its size and more prominent markings. It approaches nearer to the race *neocles* Mabille, 1891, of which the type is said to come from Cooktown.

Described from two males and one female from Bathurst Is., N.T., in October.

*SUNIANA SUNIAS SAUDA*, n. subsp.

This race from Port Darwin differs from the other Australian races in being paler yellow both above and below.

*TELICOTA EUROTAS* Felder.

*Pamphila eurotas* Felder, Sitz. Akad. Wiss. Math.-Nat. Wien, xl, 1860, 462.

This species differs from the others in the genus in having the uncus undivided. The race in northern New South Wales is *eurychlora* Lower, 1908. Mr. F. H. Taylor has sent me specimens from the Cairns District, so this added material shows that North Queensland specimens form a distinct race. The Australian Museum has specimens from Aru, which have dark orange markings on the upper-side and the markings on the underside usually more defined than in the Australian races.

*TELICOTA EUROTAS LACONIA*, n. subsp.

In the male, this race differs from *eurychlora* in having the orange markings above darker. On the forewing the three subapical elongate spots are not so definitely connected with the costal streak; the spots in 4 and 5 are smaller and the discal band from 1a to 4 narrower and with straighter edges, especially on the inner side. On the upperside of the hindwing the cell spot is smaller and in all specimens I have seen the broad band extends into 6. Beneath the general colour is more orange and the markings more distinct than in *eurychlora*. The female has the three subapical spots of the forewing quite separate from the cell spot.

The holotype is from Cairns in May; three males and a female from Cairns in September, and two males and a female from the Herbert River in September.

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# THE DISTRIBUTION OF SOOTY-MOULD FUNGI AND ITS RELATION TO CERTAIN ASPECTS OF THEIR PHYSIOLOGY.

By LILIAN FRASER, M.Sc., Linnean Macleay Fellow of the Society in Botany.

(Plate iii; twelve Text-figures.)

[Read 28th April, 1937.]

A sooty-mould colony usually consists of a number of different species growing together, as has been described in a previous paper (Fraser, 1933). The constituent fungi may be indiscriminately mixed, or may be more or less segregated. On a leaf or on adjoining leaves there may be colonies of a single species, and in other places several may be growing together.

The appearance of a sooty-mould colony is determined by the dominant fungus. *Capnodium salicinum*, for example, forms a thin black colony. *Limacinia concinna* and *Capnodium moniliforme* form thick felt-like moulds. *C. elegans* forms a thin cottony mould on account of the upright nature of the hyphae.

The appearance of the colony may vary with the habitat. On stems *Capnodium mucronatum* forms erect fascicles of hyphae up to 2 cm. high. Such a mass of mycelium could not be supported on a leaf, so that epiphyllous colonies of *C. mucronatum* are relatively thin and consist of loosely interwoven hyphae.

Sooty-moulds are found in all sorts of localities but not all the species are found throughout the whole range. Certain distinct associations are characteristic of sunny, shaded and densely shaded, and of dry and moist localities.

In this paper an attempt is made first to interpret this distribution in nature on the basis of the physiological properties of the individual species, and secondly to examine the reason for the limitation of sooty-mould-forming fungi to the excretions of scale insects.

## Methods of Growth of Naturally-Occurring Sooty-Mould Fungi.

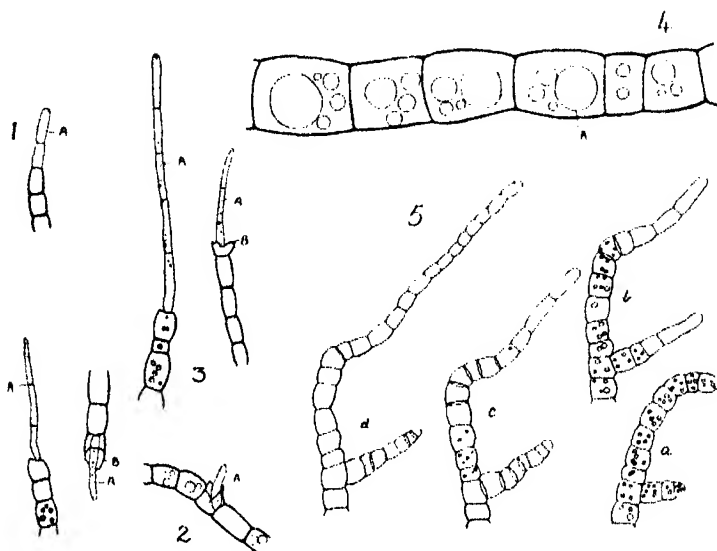
A property shared by all sooty-mould-forming fungi is the ability to make use of intermittent moist conditions of the atmosphere for the purposes of growth. It is apparent that this must be a physiological factor of great importance.

If a fragment of sooty-mould is kept in a damp atmosphere or in water, growth takes place at all hyphal apices (Text-fig. 1), and from broken ends (Text-fig. 2). Text-figures 1 and 2 show the amount of new growth made in 12 hours by *Limacinia concinna*. The walls of the new cells are light coloured and therefore easily recognizable. Text-figure 3 shows the amount of growth made in 36 hours. Living sooty-mould cells contain large quantities of an oil-like substance (A in Text-fig. 4). The amount of this substance present in the cells behind the new growth is always found to be much decreased (Text-figs. 3, 5). Text-figure 5a shows a hypha as it appeared at the commencement of the growth test. The oil-like substance is present in all the cells. Text-figure 5b shows the amount of growth made in water after 12 hours, and Text-figures 5c and 5d show the amount of growth after 36 and 60 hours in water respectively. The food



reserve is then seen to be entirely depleted. Loss of food reserve takes place progressively from the cells nearest the new growth to those furthest from it.

If a sooty-mould mycelium growing under natural conditions is examined microscopically after a dewy night, evidence of fresh growth can be seen in the presence of thin-walled cells at the apices of the hyphae.



Text-figs. 1-5.

1.—A hypha of *Limacinia concinna* showing new growth (A) from the apex after 12 hours in water.  $\times 285$ .

2.—Broken hyphae of *Limacinia concinna* showing new growth (A) after 12 hours in water, and the jagged appearance of the broken walls (B).  $\times 285$ .

3.—Hyphae of *Limacinia concinna* showing the amount of new growth made after 36 hours in water (A), and the reduction in the amount of oil-like substance in the old cells adjoining the new growth.  $\times 285$ .

4.—Cells of *Limacinia concinna* showing the presence of drops of an oil-like substance (A).  $\times 1,000$ .

5.—A hypha of *Limacinia concinna* showing the disappearance of oil-like substance from the old cells with increase in number of new cells. 5a, original hypha. 5b, after 12 hours in water. 5c, after 36 hours in water. 5d, after 60 hours in water.  $\times 285$ .

Growth of a sooty-mould colony seems therefore to take place as follows: the mould cell absorbs scale-insect excretion as it is available, and stores up food materials. Then when sufficient water is available, during rain or on a dewy night, growth is made and the reserve foods are drawn upon. It is obvious that little growth can be made during hot or dry weather.

The growth rate of sooty-moulds over a long period is therefore necessarily slow. This has been demonstrated in the case of *Brefeldiella brasiliensis*, for the growth rate of which exact data have been obtained. Twenty-two thallii of this species growing on leaves were measured at intervals. Measurements were taken always along the same two diameters at right angles. The average increase in diameter is given in Table 1.

TABLE 1.

Time in weeks from the commencement of the experiment .. .. .	0	2	4	9	10	11
Average diameter of colony in mm. .. .. .	0.87	0.96	1.0	1.2	1.24	1.27

*Brefeldiella* is specially suitable for such measurements as its flat thallus grows at the margin only and not in thickness, so that the total amount of growth made can be found by measuring the diameter from time to time. Exact measurements can not be made in the case of the members of the Capnodiaceae, which form mixed colonies growing in thickness as well as in diameter and from many points. The growth rate, in the field, of the members of the Capnodiaceae is faster than that of *Brefeldiella*. *Limacinia concinna*, for example, can form a thin mould over the surface of a leaf  $7 \times 2.5$  cm. in size in two weeks during moist weather.

*Natural Associations of Sooty-Mould Fungi.*

The following situations are inhabited by characteristic associations of sooty-mould fungi.

(1). Sunny open habitats where sooty-moulds are exposed to maximum heat, light and desiccation.

Fungi: *Capnodium salicinum*, *C. salicinum* var. *uniseptatum*, *C. Walteri*, *C. anonae* (imperfect stage only), *C. fuliginodes* (imperfect stage only), *C. australe*, *Atichia glomerulosa*, *Dematium pullulans* and *Cladosporium herbarum*.

Hosts: *Bursaria spinosa* (attacked by *Ceroplastes destructor* and *Eriococcus eucalypti*), *Pittosporum undulatum* (*Ceroplastes destructor*), *Eugenia* sp. (*Ceroplastes rubens*), *Eucalyptus* spp. (*Ctenochiton eucalypti*), *Leptospermum flavescens*, *L. scoparium*, *L. lanigerum* (*Tachardia melaleucae*).

(2). Habitats which are moister than (1) and are exposed to light and heat for shorter periods.

Fungi: *Capnodium anonae* (perfect and imperfect stages), *C. anonae* var. *obscurum*, *C. fuliginodes* (perfect and imperfect stages), *C. fuliginodes* var. *grandisporum*, *Limacinia concinna*, *Aithaloderma ferrugineum*, *Atichia Millardeti*, *Caldariomyces* sp. 1, *Brefeldiella brasiliensis*.

Hosts: *Ceratopetalum apetalum* (attacked by *Dactylopius* sp.), *Elaeodendron australe* (*Ceroplastes destructor*), *Eugenia* sp. (*Ceroplastes rubens*), *Synoum glandulosum* (*Ceroplastes destructor*), rarely *Bursaria spinosa* (*Ceroplastes destructor*).

All the fungi of (1) may also occur in this association, their fructifications being characteristically larger than in more open situations.

(3). Habitats which are moister than the preceding, obtaining as a rule in rain forests or in damp shady gullies where humidity is always high.

(a). Exposed to sunlight for at least part of the day.

Fungi: *Capnodium elegans*, *C. mucronatum*, *C. moniliforme*, *Henningsomyces affine*, *Scorias philippinensis*, *Microxyphium* sp. 1, *M.* sp. 2, *Caldariomyces* sp. 2, *Atichia Millardeti*. The fungi of (2) occur occasionally, those of (1) rarely.

Hosts: Rain forest trees attacked by the scale insects already mentioned, especially *Doryphora sassafras* attacked by *Aspidiotus rossi*.

(b). Not or rarely exposed to sunlight, often at some distance from the source of food.

Fungi: *Chaetothyrium* spp., *Atichia* Millardetii, *Trichopeltis reptans*, *Trichothallus hawaiiensis*, *Brefeldiella brasiliensis*, *Triposporium* sp., *Phycopsis vanillae*.

Hosts: Rain forest trees attacked by the scale insects mentioned above.

Certain species of fungi are not often associated with each other, though occurring in the same sort of situation. In some cases several species may occur on the same leaf but their mycelium does not become mixed and the colonies remain distinct though in contact at the edges. This has been observed in the case of some species of *Chaetothyrium*, especially when *C. fusisporum* is present (Plate iii, fig. 1).

In Table 2 a list is given of the species of sooty-mould fungi found growing with a selected number of types, to illustrate the associations recorded above.

TABLE 2.

Type.	Associated Fungi.	Number of Times Association has been Found.	Total Number of Times Type has been Collected.
<i>Capnodium anonae</i> .. ..	<i>Capnodium anonae</i> var. <i>obscurum</i> ..	5	61
	<i>C. Walleri</i> .. ..	21	
	<i>C. salicinum</i> .. ..	3	
	<i>C. salicinum</i> var. <i>uniseptatum</i> ..	12	
	<i>C. moniliforme</i> .. ..	6	
	<i>C. fuliginodes</i> .. ..	15	
	<i>C. australe</i> .. ..	1	
	<i>C. elegans</i> .. ..	2	
	<i>C. mucronatum</i> .. ..	2	
	<i>Aithaloderma ferrugineum</i> .. ..	9	
	<i>Caldariomyces</i> sp. 1 .. ..	1	
	<i>Caldariomyces</i> sp. 2 .. ..	10	
	<i>Atichia</i> Millardetii .. ..	5	
	<i>Microzyphium</i> sp. 1 .. ..	7	
	<i>Microzyphium</i> sp. 2 .. ..	3	
	<i>Chaetothyrium fusisporum</i> .. ..	1	
	<i>Henningsomyces affinis</i> .. ..	1	
	<i>Limacinia concinna</i> .. ..	6	
<i>Capnodium Walleri</i> .. ..	<i>Capnodium anonae</i> .. ..	21	33
	<i>C. fuliginodes</i> .. ..	9	
	<i>C. salicinum</i> var. <i>uniseptatum</i> ..	7	
	<i>C. salicinum</i> .. ..	3	
	<i>C. australe</i> .. ..	2	
	<i>Limacinia concinna</i> .. ..	2	
	<i>Capnodium anonae</i> var. <i>obscurum</i> ..	1	
	<i>Aithaloderma ferrugineum</i> .. ..	1	
	<i>Atichia</i> Millardetii .. ..	1	
<i>Aithaloderma ferrugineum</i> .. ..	<i>Capnodium anonae</i> .. ..	9	42
	<i>Atichia</i> Millardetii .. ..	9	
	<i>Brefeldiella brasiliensis</i> .. ..	6	
	<i>Limacinia concinna</i> .. ..	5	
	<i>Caldariomyces</i> sp. 2 .. ..	3	
	<i>Capnodium salicinum</i> var. <i>uniseptatum</i> ..	3	
	<i>Microzyphium</i> sp. 1 .. ..	3	
	<i>Henningsomyces affinis</i> .. ..	2	
	<i>Capnodium moniliforme</i> .. ..	1	
	<i>C. elegans</i> .. ..	1	
	<i>C. fuliginodes</i> .. ..	1	

<i>Capnodium elegans</i> .. ..	<i>Capnodium mucronatum</i> .. ..	4	10
	<i>C. moniliforme</i> .. ..	4	
	<i>C. anonae</i> .. ..	2	
	<i>Scorias philippinensis</i> .. ..	2	
	<i>Limacinia concinna</i> .. ..	1	
	<i>Aithaloderma ferruginea</i> .. ..	1	
	<i>Chaetothyrium roseosporum</i> .. ..	1	
<i>Capnodium moniliforme</i> .. ..	<i>Capnodium mucronatum</i> .. ..	4	24
	<i>C. elegans</i> .. ..	4	
	<i>C. anonae</i> .. ..	6	
	<i>Microzyphium</i> sp. 1 .. ..	4	
	<i>Caldariomyces</i> sp. 2 .. ..	5	
	<i>Atichia Millardeti</i> .. ..	4	
	<i>Trichopeltis reptans</i> .. ..	2	
	<i>Brefeldiella brasiliensis</i> .. ..	1	
	<i>Scorias philippinensis</i> .. ..	1	
	<i>Limacinia concinna</i> .. ..	1	
<i>Chaetothyrium roseosporum</i> .. ..	<i>Atichia Millardeti</i> .. ..	2	11
	<i>Chaetothyrium cinereum</i> .. ..	2	
	<i>Capnodium elegans</i> .. ..	1	
	<i>Trichopeltis reptans</i> .. ..	1	
	<i>Chaetothyrium fusisporum</i> .. ..	1	
<i>Atichia Millardeti</i> .. ..	<i>Chaetothyrium fusisporum</i> .. ..	18	58
	<i>Brefeldiella brasiliensis</i> .. ..	9	
	<i>Aithaloderma ferruginea</i> .. ..	9	
	<i>Trichopeltis reptans</i> .. ..	6	
	<i>Chaetothyrium griseolum</i> .. ..	5	
	<i>Capnodium anonae</i> .. ..	5	
	<i>C. moniliforme</i> .. ..	4	
	<i>Phycopsis vanillae</i> .. ..	2	
	<i>Caldariomyces</i> sp. 2 .. ..	2	
	<i>Capnodium salicinum</i> var. <i>uniseptatum</i> .. ..	1	
	<i>C. mucronatum</i> .. ..	1	
	<i>C. Walteri</i> .. ..	1	
	<i>Microzyphium</i> sp. 1 .. ..	1	
	<i>Limacinia concinna</i> .. ..	1	
	<i>Chaetothyrium depressum</i> .. ..	1	
	<i>C. fuscum</i> .. ..	1	
	<i>C. roseosporum</i> .. ..	2	
	<i>C. cinereum</i> .. ..	1	

It has been found that *Capnodium anonae* is the commonest and most widespread sooty-mould species. It is found growing in many localities in all kinds of associations. This is shown in Table 2 by the number and variety of fungi associated with it. Other species are seen to be more limited in their associations. The species found growing with *Capnodium Walteri*, *C. elegans*, *C. moniliforme*, *Aithaloderma ferruginea*, *Chaetothyrium roseosporum*, and *Atichia Millardeti* are chiefly those of the same association class.

#### Heat Resistance of Naturally-Occurring Sooty-Mould Fungi.

As sooty-mould fungi show such a marked degree of natural grouping, an attempt was made to trace the cause. One probable reason seemed to be that some fungi might be more resistant to heat than others. Consequently as many sooty-mould fungi as were available were tested for their reactions to heat.

**Methods.**—After some experimenting the following method was adopted as being simple, quick and suitable for treating large numbers of fungi at the same

time. Fragments of the fungus to be tested were placed in four test-tubes, either dry or in water, according to whether dry or wet heat was to be used. The test-tubes were then placed in a water bath at the required temperature so that they were immersed to about half their height. The tubes were removed from the water bath after 5, 10, 20 and 40 minutes of heating. It was found that the temperature inside the tubes reached that of the water bath in approximately three and a half minutes, and this extra time was given in each case. Hanging-drop cultures were made of the treated fragments of mycelium and they were examined for signs of growth after one week.

In Tables 3 and 4 the results of these experiments are given.

TABLE 3.  
*Resistance of Sooty-Mould Fungi to Moist Heat.*

Temperature in degrees Centigrade .. ..	30				35				40			
Time of treatment in minutes .. .. .	5	10	20	40	5	10	20	40	5	10	20	40
Fungus.												
<i>Limacinia concinna</i> .. .. .	3	3	3	3	3	3	3	3	2	1	—	—
<i>Capnodium fuliginodes</i> .. .. .	3	3	3	3	3	3	3	3	2	2	—	—
<i>Capnodium Walteri</i> .. .. .	3	3	3	3	3	3	3	3	1	—	—	—
<i>Capnodium elegans</i> .. .. .	3	3	2	1	2	2	1	1	—	—	—	—
<i>Capnodium moniliforme</i> .. .. .	2	2	1	1	—	—	—	—	—	—	—	—
<i>Capnodium mucronatum</i> .. .. .	3	3	3	3	3	3	3	3	2	2	1	—
<i>Capnodium salicinum</i> .. .. .	3	3	3	3	3	2	1	1	—	—	—	—
<i>Capnodium anonae</i> .. .. .	3	3	3	3	3	3	3	2	2	2	1	—
<i>Capnodium anonae</i> var. <i>obscurum</i> .. .. .	3	2	2	2	3	2	2	1	—	—	—	—
<i>Chaetothyrium fuscesporum</i> .. .. .	3	3	3	3	3	3	3	2	2	2	2	—
<i>Aithaloderma ferruginea</i> .. .. .	3	3	3	3	3	3	3	3	3	2	1	—
<i>Chaetothyrium cinereum</i> .. .. .	3	2	2	2	3	2	2	2	2	—	—	—
<i>Microxyphium</i> sp. 1 .. .. .	3	3	3	3	3	3	3	2	3	2	—	—
<i>Trichopeltis reptans</i> .. .. .	3	3	3	3	3	3	3	2	—	—	—	—
<i>Cladosporium herbarum</i> .. .. .	3	3	2	2	1	1	1	1	—	—	—	—
<i>Penicillium expansum</i> .. .. .	3	2	2	1	1	—	—	—	—	—	—	—

The condition of the fungus after treatment is shown arbitrarily as follows:

- indicates that no growth has taken place in the hanging-drop culture and the fungus is considered to be dead.
- 3 indicates that growth equal to that of the untreated control has taken place.
- 2 indicates that a fair amount of growth has taken place.
- 1 indicates that very little growth has taken place, only an occasional hypha being alive.

TABLE 4.  
Resistance of Sooty-Mould Fungi to Dry Heat.

Temperature in degrees Centigrade ..	55				60				65				70				75			
Time of treatment in minutes ..	5	10	20	40	5	10	20	40	5	10	20	40	5	10	20	40	5	10	20	40
Fungus.																				
<i>Limacinia concinna</i> ..	..	..	2	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Capnodium fuliginodes</i> ..	..	..	3	2	2	2	2	2	1	1	2	2	1	—	2	1	1	—	—	—
<i>Capnodium Walleri</i> ..	..	..	3	3	3	2	3	3	2	2	3	3	2	1	3	3	2	1	2	2
<i>Capnodium elegans</i> ..	..	..	3	3	2	2	3	2	2	2	2	2	1	1	—	—	—	—	—	—
<i>Capnodium moniliforme</i> ..	..	..	3	2	1	1	2	1	1	1	2	1	1	—	1	1	1	—	—	—
<i>Capnodium mucronatum</i> ..	..	..	3	3	3	3	3	3	3	3	3	3	2	2	3	3	2	1	—	—
<i>Capnodium salicinum</i> ..	..	..	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	1
<i>Capnodium anonae</i> ..	..	..	3	3	3	3	3	3	3	3	2	2	1	—	—	—	—	—	—	—
<i>Capnodium anonas</i> var. <i>obacurum</i>	3	3	3	2	3	3	2	1	2	2	—	—	2	1	—	—	—	—	—	—
<i>Chaetothyrium fusisporum</i> ..	..	..	3	3	3	3	3	3	3	3	2	2	2	1	2	1	1	1	2	1
<i>Chaetothyrium cinereum</i> ..	..	..	3	3	3	3	3	3	2	2	3	3	3	2	2	2	2	—	—	—
<i>Chaetothyrium roseosporum</i> ..	..	..	3	3	3	3	3	3	3	3	2	2	1	1	1	1	—	—	—	—
<i>Athlodermis ferruginea</i> ..	..	..	3	3	2	2	3	2	2	2	2	2	2	1	2	2	2	—	—	—
<i>Microzophium</i> sp. 1 ..	..	..	3	3	2	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Trichopeltis reptans</i> ..	..	..	3	3	3	3	3	3	3	1	2	2	2	1	—	—	—	—	—	—
<i>Triposporium</i> sp. ..	..	..	3	3	3	2	3	2	2	2	3	2	2	1	2	2	2	1	—	—
<i>Cladosporium herbarum</i> ..	..	..	3	3	3	3	3	2	2	2	2	2	1	1	1	1	—	—	—	—
<i>Penicillium expansum</i> ..	..	..	2	2	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—

The condition of the fungus after treatment is shown arbitrarily as follows:

- indicates that no growth has taken place in the hanging-drop culture and the fungus is considered to be dead.
- 3 indicates that growth equal to that of the untreated control has taken place.
- 2 indicates that a fair amount of growth has taken place.
- 1 indicates that very little growth has taken place, only an occasional hypha being alive.

These tables show that there is a striking difference between the resistance shown by fungi to wet and dry heat. None of the fungi tested were able to withstand a temperature higher than 45° C. in water, even for so short a time as 5 minutes.

There does not appear to be any exact correlation between ability to resist wet heat and ability to resist dry heat. For example, *Limacinia concinna* can remain alive after 10 minutes' exposure to a temperature of 40° C., wet heat, but is killed by an exposure of 5 minutes to 60° C., dry heat, whereas *Capnodium*

*elegans* and *C. salicinum* are killed after 5 minutes at 40° C., wet heat, but are resistant to 65° C., dry heat, for 40 minutes.

The following classes of sooty-mould fungi can be distinguished on the basis of their resistance to dry heat:

(1).—Very resistant, comprising species which can withstand a temperature of 70° C. for 40 minutes.

Species: *Capnodium Walteri*, *C. mucronatum*, *C. salicinum*, *Chaetothyrium fusisporum*, *Triposporium* sp.

TABLE 5.  
Resistance of Cultivated Sooty-Mould Fungi to Moist Heat.

Temperature in degrees Centigrade .. ..		30				35				40			
Time of treatment in minutes .. ..		5	10	20	40	5	10	20	40	5	10	20	40
Fungus.	Medium.												
<i>Capnodium salicinum</i> .. ..	S	3	2	2	2	2	2	2	2	1	1	—	—
	P	3	3	3	2	2	2	2	2	—	—	—	—
	G	2	2	—	—	1	—	—	—	—	—	—	—
<i>Capnodium salicinum</i> var. <i>uniseptatum</i>	S	3	3	3	3	3	3	2	2	3	3	2	1
	P	3	3	3	2	3	3	2	2	2	—	—	—
	G	2	2	—	—	1	—	—	—	1	—	—	—
<i>Athlodermis ferruginea</i> .. ..	S	3	3	3	3	3	2	2	2	3	1	—	—
	P	3	3	2	2	2	1	—	—	—	—	—	—
	G	2	1	—	—	1	1	—	—	1	1	—	—
<i>Capnodium fuliginodes</i> .. ..	S	3	3	3	3	3	3	3	2	3	2	2	2
	P	3	3	3	3	3	3	3	2	2	2	2	1
	G	3	3	2	2	3	2	2	2	1	—	—	—
<i>Capnodium Walteri</i> .. ..	S	3	3	3	3	3	3	2	2	2	1	1	1
	P	3	3	3	3	3	2	2	2	1	1	1	—
	G	3	2	2	2	3	2	1	1	1	—	—	—
<i>Chaetothyrium cinereum</i> .. ..	S	3	3	3	3	3	3	3	2	3	3	1	1
	P	2	1	—	—	—	—	—	—	—	—	—	—
	G	1	1	—	—	—	—	—	—	—	—	—	—
<i>Limacina concinna</i> .. ..	S	3	3	3	3	3	3	3	2	3	3	1	1
	P	2	1	—	—	—	—	—	—	—	—	—	—
	G	1	1	—	—	—	—	—	—	—	—	—	—
<i>Triposporium</i> sp. .. ..	S	3	3	3	3	2	2	2	—	2	—	—	—
	P	3	3	3	3	3	2	2	2	2	1	—	—
	G	3	1	—	—	1	1	—	—	1	1	—	—
<i>Dematiu pullulans</i> .. ..	S	3	3	3	2	1	1	—	—	—	—	—	—
	P	3	3	3	2	3	2	2	2	1	1	1	—
	G	3	3	3	3	2	2	2	2	—	—	—	—

The condition of the fungus after treatment is shown arbitrarily as follows:

— indicates that no growth has taken place in the hanging-drop culture and the fungus is considered to be dead.

3 indicates that growth equal to that of the untreated control has taken place.

2 indicates that a fair amount of growth has taken place.

1 indicates that very little growth has taken place, only an occasional hypha being alive.

P, potato glucose solution.—S, unpurified adonite solution.—G, glucose salts solution.

(2).—Resistant, comprising species which can withstand a temperature of 65° C. for 20 minutes.

Species: *Capnodium fuliginodes*, *C. elegans*, *C. anonae*, *C. moniliforme*, *C. anonae* var. *obscurum*, *Aithaloderma ferruginea*, *Chaetothyrium roseosporum*, *C. cinereum*, *Trichopeltis reptans*, *Cladosporium herbarum*.

(3).—Not resistant, comprising species which can not withstand temperatures above 60° C. for more than 10 minutes.

TABLE 6.  
*Resistance of Cultivated Sooty-Mould Fungi to Dry Heat.*

Temperature in degrees Centigrade .. ..		55				60				65				70			
Time of treatment in minutes .. ..		5	10	20	40	5	10	20	40	5	10	20	40	5	10	20	40
Fungus.	Medium.																
<i>Capnodium salicinum</i> .. ..	S	3	3	3	3	2	2	2	1	2	2	2	—	2	—	—	—
	P	3	3	3	3	2	2	2	1	3	2	2	—	2	2	2	—
	G	2	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Capnodium salicinum</i> var. <i>uniseptatum</i>	S	3	3	3	3	3	3	2	2	3	3	2	2	3	3	2	2
	P	3	3	3	3	3	1	1	—	—	—	—	—	—	—	—	—
	G	3	3	1	—	2	2	—	—	2	2	—	—	—	—	—	—
<i>Aithaloderma ferruginea</i> .. ..	S	3	3	3	2	3	2	2	2	1	1	—	—	—	—	—	—
	P	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—
	G	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Capnodium fuliginodes</i> .. ..	S	3	3	3	3	3	3	3	2	3	3	3	—	—	—	—	—
	P	3	3	3	3	3	3	2	—	3	3	2	—	—	—	—	—
	G	3	3	2	2	2	1	1	—	—	—	—	—	—	—	—	—
<i>Capnodium Walteri</i> .. ..	S	3	3	3	3	2	2	2	2	2	2	2	2	—	—	—	—
	P	3	3	2	2	2	1	1	1	1	1	1	—	—	—	—	—
	G	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Chaetothyrium cinereum</i> .. ..	S	3	3	3	3	1	1	—	—	—	—	—	—	—	—	—	—
	P	3	3	3	2	1	1	—	—	—	—	—	—	—	—	—	—
	G	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Limacina concinna</i> .. ..	S	3	3	3	3	3	3	3	2	1	1	—	—	—	—	—	—
	P	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—
	G	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Triposporium</i> sp. .. ..	S	3	3	3	2	2	2	2	1	1	1	1	—	—	—	—	—
	P	3	3	3	2	2	2	2	1	2	2	2	1	—	—	—	—
	G	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Dematiu pullulans</i> .. ..	S	3	2	1	—	1	—	—	—	—	—	—	—	—	—	—	—
	P	3	3	1	1	1	1	—	—	—	—	—	—	—	—	—	—
	G	3	3	3	3	3	3	3	3	3	3	3	3	—	—	—	—

The condition of the fungus after treatment is shown arbitrarily as follows:

— indicates that no growth has taken place in the hanging-drop culture and the fungus is considered to be dead.

3 indicates that growth equal to that of the untreated control has taken place.

2 indicates that a fair amount of growth has taken place.

1 indicates that very little growth has taken place, only an occasional hypha being alive.

P, potato glucose solution.—S, unpurified adonite solution.—G, glucose salts solution.



Species: *Limacina concinna*, *Microxyphium* sp. 1, *Penicillium expansum* (control).

It can be seen from Table 3 that the distribution of sooty-mould fungi can not be explained by their powers of heat resistance alone, for, although the species of the non-resistant class occur in the less exposed situations in nature, others which occur in similar situations are strikingly resistant to heat, e.g., *Chaetothyrium* spp.

*Resistance of Cultivated Sooty-Mould Fungi to High Temperatures.*

In this series of experiments three media were used for the cultivation of the fungi, as it was thought that the composition of the medium might influence the resistance of the fungus to some extent. The media were as follows:

(1) Unpurified adonite 2 gm., water 100 c.c. (S in Table 5).

(2) Standard potato glucose solution (P in Table 5).

(3) Glucose 2 gm., sodium nitrate 2 gm., potassium dihydrogen phosphate 0.5 gm., magnesium sulphate 0.25 gm., water 100 c.c. (G in Table 5).

The fungi were grown for three weeks on glass-wool soaked with the culture medium in Petri dishes, and were then allowed to become air-dry at laboratory temperature and humidity under aseptic conditions before testing for heat resistance. The treatment adopted was the same as for the naturally-occurring sooty-moulds. The results are given in Tables 5 and 6.

TABLE 7.

*Resistance of Sooty-Mould Fungi Grown on Media of Different Concentrations to Dry Heat.*

Temperature in degrees Centigrade .. ..		45				50				55				60			
Time of treatment in minutes .. ..		5	10	20	40	5	10	20	40	5	10	20	40	5	10	20	40
Fungus.	Concentration of Glucose in Medium.																
	%																
<i>Caldariomyces</i> sp. 1 .. ..	0	3	3	3	2	2	1	1	1	1	—	—	—	—	—	—	—
	0.5	3	3	3	2	1	1	1	1	2	2	—	—	—	—	—	—
	2.0	3	3	2	2	3	2	1	1	2	2	1	—	2	—	—	—
	10.0	3	2	2	1	2	1	1	—	2	2	1	—	2	2	—	—
	25.0	2	1	—	—	1	1	—	—	1	1	—	—	—	—	—	—
<i>Capnodium fuliginodes</i> .. ..	0	3	3	3	3	2	3	3	3	2	1	—	—	—	—	—	—
	0.5	3	3	3	2	3	2	1	1	3	2	1	1	1	—	—	—
	2.0	3	3	3	2	3	3	3	2	3	2	1	—	1	—	—	—
	10.0	3	2	2	—	1	—	—	—	—	—	—	—	—	—	—	—
	25.0	3	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Dematiu pullulans</i> .. ..	0	2	1	—	—	2	1	—	—	2	—	—	—	—	—	—	—
	0.5	2	2	—	—	1	—	—	—	1	—	—	—	—	—	—	—
	2.0	3	3	1	1	3	2	1	1	2	1	1	1	1	—	—	—
	10.0	3	2	2	2	3	2	1	1	2	2	1	1	2	2	—	—
	25.0	3	3	2	1	3	2	1	—	2	2	—	—	—	—	—	—

The condition of the fungus after treatment is shown arbitrarily as follows:

- indicates that no growth has taken place in the hanging-drop culture and the fungus is considered to be dead.
- 3 indicates that growth equal to that of the untreated control has taken place.
- 2 indicates that a fair amount of growth has taken place.
- 1 indicates that very little growth has taken place, only an occasional hypha being alive.

The results obtained for resistance to wet heat are similar to those obtained for naturally-occurring sooty-mould species. All species except *Dematium pullulans* showed greater resistance on unpurified adonite media than on potato solution or glucose salts solution. From an examination of Table 7 it can be seen that this was also the case when dry heat was tested.

On the whole, fungi in culture are less resistant to heating than are the same species when growing in their natural habitat. An exception to this is *Limacinia concinna*, which is more resistant in culture.

*The Effect of Altering the Concentration of the Culture Medium on the Heat Resistance of Sooty-Mould Fungi.*

It is well known that certain higher plants, e.g., *Rhus*, *Peganum*, etc. (see Maximov, 1929, p. 271 et seq.), which can endure long periods of desiccation unharmed, are characterized by cell sap of high osmotic pressure. The osmotic pressure of the cell sap of naturally-occurring sooty-moulds has been found to vary from 70 to 95 atmospheres. If the high osmotic pressure has any direct bearing on the heat-resisting powers of the cell, it should be possible, by raising or lowering the osmotic pressure, to increase or decrease the degree of resistance. This is most readily done by raising or lowering the concentration of the culture medium. The powers of heat-resistance of mycelium grown in solutions of various concentrations of glucose were therefore tested. Potato extract solutions were used with 0%, 0.5%, 2%, 10%, and 25% sugar. The fungi used in these experiments were *Capnodium fuliginodes*, *Caldariomyces* sp. 1, and *Dematium pullulans*. One set of cultures three weeks old was used for tests with wet heat. Another set of the same age was allowed to dry slowly at laboratory temperature and humidity. These were then used for tests with dry heat.

In Table 7 the result is shown of experiments using dry heat. It can be seen that resistance was slightly less in media of high and low sugar concentration than in media of medium concentration in the case of *Capnodium fuliginodes* and *Caldariomyces* sp. 1. For *Capnodium* the optimum concentration is 0.5-2.0%, and for *Caldariomyces* 2-10%. In the case of *Dematium pullulans* low concentrations reduced the powers of heat-resistance to a greater extent than in the other species, but high concentrations reduced it to a lesser extent. The optimum concentration was 10%.

Similar results were obtained using wet heat, but, as before, the temperature necessary to cause death was lower.

It appears, therefore, that in the case of these fungi there is no direct relationship between osmotic pressure and heat resistance. For each species there is an optimum concentration of medium, above and below which heat-resistance falls off.

A series of experiments in which different concentrations of nitrogen were used was made. The results showed that high and low concentrations reduced the heat-resistance of all species to about the same extent.

*Resistance of Sooty-Mould Fungi to Low Temperatures.*

The species of naturally-occurring and cultivated sooty-moulds which had been tested for heat-resistance were subjected to low temperatures to ascertain their powers of resistance to cold. The procedure adopted was similar to that used in the heat-resistance experiments. Pieces of mycelium were placed in test-tubes, dry, or with a little water, according to whether dry or wet temperatures were to be tested, and were partly immersed in a water bath. The temperature

of the water bath was controlled by the addition of ice and salt. The following temperatures were used:  $-15^{\circ}\text{C.}$ ,  $0^{\circ}\text{C.}$ ,  $2^{\circ}\text{C.}$ ,  $5^{\circ}\text{C.}$

All the species were able to withstand these temperatures without injury, both in the wet and in the dry condition.

*Resistance of Sooty-Mould Fungi to Desiccation.*

Material of the species of fungi which had been collected for heat-resistance tests was kept at laboratory temperature and tested weekly for viability. Material of the cultivated species used in the heat tests was also treated in this way.

The results are given in Tables 8 and 9. From these it can be seen that the naturally-occurring sooty-mould fungi can be grouped into the following classes on the basis of their ability to resist periods of desiccation:

- (1).—Very Resistant, comprising species viable after 10 weeks without water.  
Species: *Capnodium salicinum*, *C. Walteri*, *C. mucronatum*.
- (2).—Resistant, comprising species viable after 5 weeks without water.  
Species: *Capnodium elegans*, *C. anonae*, *C. moniliforme*, *Microxyphium* sp. 1.
- (3).—Not Resistant, comprising species which are dead after 4 weeks without water.  
Species: *Limacinia concinna*, *Chaetothyrium roseosporum*, *C. fusisporum*, *C. cinereum*, *Trichopeltis reptans*, *Aithaloderma ferruginea*, *Triposporium* sp.

It can be seen that with a few exceptions, the distribution of those species whose associations could not be explained on the basis of their powers of heat-resistance can be explained on the basis of their resistance or susceptibility to desiccation.

TABLE 8.  
*The Resistance to Desiccation of Naturally-Occurring Sooty-Mould Fungi.*

Period of desiccation in weeks	1	2	3	4	5	6	7	8	9	10	11
Fungus.											
<i>Capnodium salicinum</i> .. .. .	3	3	3	3	3	3	3	3	3	2	—
<i>Capnodium elegans</i> .. .. .	3	3	3	2	2	1	1	1	1	—	—
<i>Capnodium moniliforme</i> .. .. .	3	3	2	2	1	1	1	—	—	—	—
<i>Capnodium anonae</i> .. .. .	3	3	2	2	2	2	2	1	—	—	—
<i>Capnodium Walteri</i> .. .. .	3	3	3	3	3	3	3	2	2	1	—
<i>Capnodium mucronatum</i> .. .. .	3	3	3	3	2	2	1	1	1	1	1
<i>Limacinia concinna</i> .. .. .	3	3	2	1	—	—	—	—	—	—	—
<i>Chaetothyrium fusisporum</i> .. .. .	3	—	—	—	—	—	—	—	—	—	—
<i>Chaetothyrium roseosporum</i> .. .. .	3	2	—	—	—	—	—	—	—	—	—
<i>Chaetothyrium cinereum</i> .. .. .	2	1	—	—	—	—	—	—	—	—	—
<i>Triposporium</i> sp. .. .. .	3	3	1	—	—	—	—	—	—	—	—
<i>Aithaloderma ferruginea</i> .. .. .	3	3	3	—	—	—	—	—	—	—	—
<i>Trichopeltis reptans</i> .. .. .	3	—	—	—	—	—	—	—	—	—	—

The condition of the fungus after treatment is shown arbitrarily as follows:

- indicates that no growth has taken place in the hanging-drop culture and the fungus is considered to be dead.
- 3 indicates that growth equal to that of the untreated control has taken place.
- 2 indicates that a fair amount of growth has taken place.
- 1 indicates that very little growth has taken place, only an occasional hypha being alive.

TABLE 9.  
The Resistance to Desiccation of Cultivated Sooty-Mould Fungi.

Period of desiccation in weeks ..		1	2	3	4	5	6	7	8	9	10	11
Fungus.	Medium.											
<i>Capnodium edicinum</i> ..	S	3	3	3	3	3	3	3	3	3	2	—
	P	3	3	3	3	2	2	2	1	1	—	—
	G	3	—	—	—	—	—	—	—	—	—	—
<i>Capnodium edicinum</i> var. <i>uniseptatum</i> .. ..	S	3	3	3	3	3	2	2	2	1	—	—
	P	3	3	3	2	2	2	1	—	—	—	—
	G	3	2	1	1	1	—	—	—	—	—	—
<i>Capnodium fuliginodes</i> ..	S	3	2	2	2	2	2	2	2	2	2	2
	P	3	3	3	3	2	2	2	2	1	1	1
	G	3	3	1	—	—	—	—	—	—	—	—
<i>Capnodium Walleri</i> ..	S	3	3	3	3	3	2	2	2	2	2	2
	P	2	1	1	1	1	1	—	—	—	—	—
	G	2	2	1	1	1	—	—	—	—	—	—
<i>Athlodermis ferruginea</i>	S	3	2	2	2	2	—	—	—	—	—	—
	P	3	2	1	—	—	—	—	—	—	—	—
	G	3	2	1	—	—	—	—	—	—	—	—
<i>Limacina concinna</i> ..	S	3	3	3	3	2	2	2	2	2	2	2
	P	2	2	1	1	1	1	—	—	—	—	—
	G	2	2	2	1	1	—	—	—	—	—	—
<i>Chaetothrium cinereum</i> ..	S	3	3	3	3	3	2	2	2	2	2	2
	P	2	1	1	1	—	—	—	—	—	—	—
	G	2	1	1	—	—	—	—	—	—	—	—
<i>Triposporium</i> sp. ..	S	3	3	3	3	3	2	2	2	2	2	—
	P	3	3	2	2	2	2	1	1	1	1	—
	G	3	2	—	—	—	—	—	—	—	—	—
<i>Dematium pullulans</i> ..	S	3	3	3	2	2	1	—	—	—	—	—
	P	3	3	2	2	2	2	2	2	—	—	—
	G	3	3	3	3	3	2	2	2	2	2	2

The condition of the fungus after treatment is shown arbitrarily as follows:

- indicates that no growth has taken place in the hanging-drop culture and the fungus is considered to be dead.
- 3 indicates that growth equal to that of the untreated control has taken place.
- 2 indicates that a fair amount of growth has taken place.
- 1 indicates that very little growth has taken place, only an occasional hypha being alive.

P, potato glucose solution.—S, unpurified adonite solution.—G, glucose salts solution.

#### Reaction of Individual Species of Sooty-Mould Fungi to Special Conditions of Nutrition.

It appeared significant that only a limited number of species of fungi should occur in sooty-mould colonies, and that most omnivorous moulds such as *Penicillium* spp. should be relatively unimportant. There seemed to be several possible reasons for the paucity of these common saprophytes. Either they might not be able to utilize "honey dew", on which sooty-moulds grow in nature, or they might not be able to withstand the conditions of desiccation, high temperature

and strong sunlight to which they would be subjected in a sooty-mould colony, or their growth might be prevented by the production of staling substances by the sooty-mould fungi. It was thought also that there might be two reasons why the Capnodiaceae, Atchiaceae and Trichopeltaceae are found only in sooty-mould colonies. Either they might be restricted to "honey dew" as a source of food, or they might be too slow-growing to compete with mould fungi in any other habitat.

Experiments have been recorded in an earlier paper (Fraser, 1934) which showed that the limitation of most sooty-mould-forming species in nature to the excretions of scale insects does not appear to be due to their inability to make use of different types of food materials.

#### a. Reaction to Adonite.

The exact nature of the food materials available to the sooty-mould fungi was apparently not known to previous workers. Arnaud (1911) alone referred to the composition of "honey dew". He considered it to be a watery solution of dextrin, gums, etc. It has been shown by Dr. V. Trikojus\* that the "honey dew" produced by the scale insect *Ceroplastes destructor* is a nearly-pure aqueous solution of adonite.

A small quantity of purified adonite was made available to the writer, and preliminary experiments were made to ascertain its effect on the growth of sooty-mould fungi. The results obtained indicated that adonite was probably a specially suitable medium for the growth of sooty-mould fungi, but it did not appear to be very suitable for the growth of *Penicillium*.

More extensive experiments were accordingly planned. Pure B.D.H. adonite of plant origin was obtained. It was thought that it might also be necessary to test adonite of scale-insect origin, so a large quantity of *Ceroplastes destructor* growing on a host tree, *Melia Azedarach* var. *australasica*, was collected. The insects were scraped off the host and heated until the wax melted and the adonite solution present in its meshes was liberated. This was strained off, filtered and evaporated to dryness. The residue consisted almost entirely of adonite, and it was not considered necessary to purify it.

The following agars were used:

(1). Unpurified adonite agar.—Unpurified adonite extracted from *Ceroplastes destructor* 2 gm., agar 2 gm., water 100 c.c.

(2). Unpurified adonite agar with the addition of salts.—Unpurified adonite 2 gm., sodium nitrate 2 gm., magnesium sulphate 0.25 gm., potassium dihydrogen phosphate 0.5 gm., agar 2 gm., water 100 c.c.

(3). Purified adonite agar.—B.D.H. adonite 2 gm., sodium nitrate 2 gm., magnesium sulphate 0.25 gm., potassium dihydrogen phosphate 0.5 gm., agar 2 gm., water 100 c.c.

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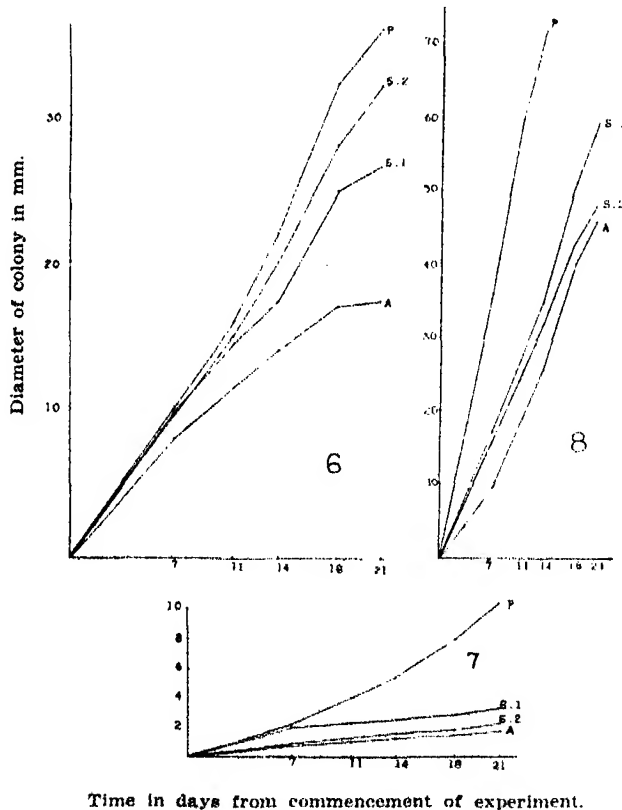
\* Dr. Trikojus kindly made available to the writer the unpublished results of his investigations on the excretions of *Ceroplastes destructor*. This insect is commonly associated with sooty-moulds. It attaches itself at an early age to the leaf or twig of a host plant and remains there throughout its life, absorbing food materials by means of thin suckers called "stylets". It excretes a waxy covering of spongy texture, which becomes several millimetres thick. The insect also produces a watery solution, the "honey dew", which contains certain by-products of its metabolism. The "honey dew" fills the meshes of the waxy covering and runs out on to the leaf or twig. Adonite (or adonitol) is a pentahydric alcohol of the constitution  $C_5H_{12}O_5$ . In fresh "honey dew" it occurs in a concentration of 6%.

(4). Potato extract agar.—Sodium nitrate 2 gm., magnesium sulphate 0.25 gm., potassium dihydrogen phosphate 0.5 gm., agar 2 gm., potato extract (200 gm. potato in 1 litre of water, boiled and filtered) 100 c.c. This was used as a control.

Petri dishes 9 cm. in diameter were poured with 10 c.c. of the required medium and inoculated with the species to be tested. The cultures were incubated at 25° C. in darkness for 21 days. All experiments were made in triplicate and the growth rate was obtained by measuring the diameters of the colonies in two directions at right angles three times weekly.

The following fungi were chosen for experiment, as they represented the two most important groups of sooty-mould fungi, the Capnodiaceae and the Fungi Imperfecti: *Capnodium fuliginodes*, *C. salicinum*, *Caldariomyces* sp. 1, *Aithaloderma ferruginea*, *Chaetothyrium griseolum* (Capnodiaceae), *Dematium pullulans*, *Penicillium expansum* (Fungi Imperfecti). *Penicillium* was included as a control.

All the fungi used were able to make a certain amount of growth on the agars on which they were tested.



Time in days from commencement of experiment.

Text-figs. 6-12.

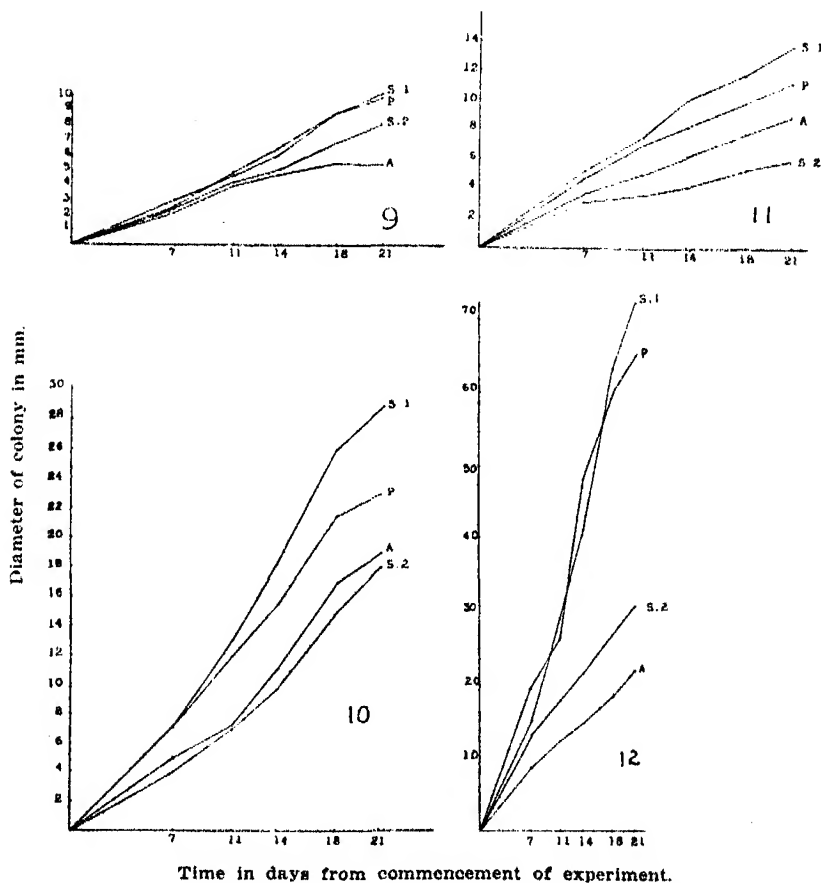
6-12.—Graphs to show growth rates on adonite (A), unpurified adonite (S. 1), unpurified adonite with the addition of salts (S. 2) and potato extract (P) agars: 6, *Caldariomyces* sp. 1; 7, *Chaetothyrium cinereum*; 8, *Penicillium expansum*; 9, *Aithaloderma ferruginea*; 10, *Capnodium fuliginodes*; 11, *Capnodium salicinum*; 12, *Dematium pullulans*.

Unpurified adonite proved a very satisfactory source of food for all the sooty-mould fungi except *Chaetothyrium*. It was found more satisfactory than the control (potato extract) for *Dematium* (S.1 in Text-fig. 12), *Capnodium fuliginodes* (S.1 in Text-fig. 10) and *C. salicinum* (S.1 in Text-fig. 11). The growth of *Penicillium* was poorer than on the control agar (Text-fig. 8).

The addition of salts (S.2 in Text-figs. 6-12) to unpurified adonite made it less suitable for all the fungi except *Caldariomyces* (Text-fig. 7).

Purified adonite was found to be less suitable for growth than unpurified adonite or potato extract (A in Text-figs. 6-12). In the case of *Caldariomyces*, *Aithaloderma* and *Chaetothyrium*, staling became more pronounced after 14 days, as shown by the flattening of the growth curve (Text-figs. 6, 7, 9).

Potato-extract agar was well utilized by all the fungi. *Penicillium*, *Caldariomyces*, and especially *Chaetothyrium* (Text-figs. 6, 7, 8) made better growth on this medium than on unpurified adonite.



From these experiments it appears that adonite excreted by *Ceroplastes destructor* is not a very suitable medium for the growth of the mould *Penicillium*, which is not a common constituent of naturally-occurring sooty moulds. On the

other hand, it was very satisfactory for the growth of all sooty-mould species tested except *Chaetothyrium*. It is also apparent that purified adonite was not so satisfactory as unpurified adonite.

So far the nature of the "honey dew" on one scale insect only has been determined, *Ceroplastes destructor* on *Bursaria spinosa*. It is quite possible that other species of scale-insect may secrete slightly different substances and that some species of sooty-mould fungi may grow particularly well on one special type of secretion.

b. Staling Phenomena shown by Sooty-Mould Fungi.

In the case of soil fungi the influence of the species on each other's growth is well known. Garrett (1934) has recently summarized and extended the knowledge on this subject. Comparatively little attention, however, has been paid to the influence of other saprophytic fungi on each other in nature.

Many workers, notably Brown (1923) and Pratt (1924a, 1924b) have discussed the problem of staling caused by the growth of fungi in agar media. As the fungus grows it produces decomposition products which diffuse out into the surrounding agar. These may accumulate in such quantities as to retard or finally stop the growth of the fungus itself, and to retard or stop the growth of another fungus growing near it.

When a fungus is grown on nutrient agar, growth takes place as a rule at the margins only, so that a flat circular colony is produced. It has been shown by Pratt (1924a) that the agar in the centre is not depleted of food materials but contains staling substances which render it unfit for further growth.

As indicated here and in an earlier paper (Fraser, 1934), sooty-mould fungi do not produce staling substances which retard their own growth to any great extent, except when the nitrogen content of the culture medium is high, or when unfavourable nitrogen compounds are present in the agar.

Many sooty-mould fungi do not form flat even colonies on agar media. They may be ridged, domed or very much raised in the centre. Moderate examples of this are shown in Plate III, figures 2 and 4, where the colonies are domed and furrowed respectively. In extreme cases the colony may become as thick as it is wide. This is due to continued growth and branching of the hyphae in the older parts, which seem to continue until all available food material is exhausted. The formation of a thick colony is especially marked on agar containing a high concentration of sugar. This method of growth furnishes additional proof that the species of sooty-moulds do not form substances which stale their own growth to any extent.

There is less likelihood of the accumulation of staling substances on a leaf surface, where they could be washed off by rain, than in an agar medium. It is evident, however, that if no rain were to fall over a period of a week or more, and if sufficient dew for growth to be made were available each night, a considerable amount of staling substances could accumulate.

To obtain further light on the problem of staling reactions, sooty-mould species were grown together in pairs on thin agar media, as staling is more readily detected in thin agar than in thick.

A series of experiments was made using potato glucose agar. The results so obtained were checked by an experiment in which unpurified adonite agar was used.

Six possible types of reaction may result when fungi are grown together in pairs on nutrient agar:



- (1). A stops growth of B, but is not itself affected by B.
- (2). A decreases the growth of B, but is not itself affected by B.
- (3). A stops or nearly stops the growth of B, and is itself slowed down by B.
- (4). A and B slow down and stop each other's growth.
- (5). A and B slow down each other's growth, but do not stop, continuing to grow over each other: 5a. Mutual effect slight; 5b. Mutual effect fairly strong.
- (6). A and B have no mutual effect, but grow over each other with undiminished vigour.

On potato dextrose agar the reactions of the pairs of fungi fall into the following classes:

Class 2	A	B
	<i>Capnodium anonas</i>	and <i>Penicillium expansum</i>
Class 3.	A	B
	<i>Microxyphium</i> sp. 1	and <i>Penicillium expansum</i>
	" "	" <i>Dematium pullulans</i>
	<i>Caldariomyces</i> sp. 1	" <i>Penicillium expansum</i>
	<i>Dematium pullulans</i>	" " "
	<i>Athaloderma ferruginea</i>	" " "
	<i>Triposporium</i> sp.	" " "
	<i>Capnodium salicinum</i> var. <i>uniseptatum</i>	" " "
	<i>Capnodium fuliginodes</i>	" " "
	<i>Limacinia concinna</i>	" " "
	<i>Triposporium</i> sp.	" <i>Limacinia concinna</i>
Class 4.	A	B
	<i>Chaetothyrum cinereum</i>	and <i>Caldariomyces</i> sp. 1
	<i>Athaloderma ferruginea</i>	" <i>Dematium pullulans</i>
	<i>Microxyphium</i> sp. 1	" " "
	<i>Caldariomyces</i> sp. 1	" <i>Capnodium salicinum</i> var. <i>uniseptatum</i>
Class 5a.	A	B
	<i>Caldariomyces</i> sp. 1	and <i>Limacinia concinna</i>
	<i>Dematium pullulans</i>	" <i>Capnodium anonas</i>
	<i>Cladosporium herbarum</i>	" <i>Athaloderma ferruginea</i>
	" "	" <i>Capnodium Walteri</i>
	<i>Chaetothyrum cinereum</i>	" <i>Penicillium expansum</i>
	<i>Capnodium fuliginodes</i>	" <i>Capnodium Walteri</i>
	" "	" <i>Cladosporium herbarum</i>
	" "	" <i>Capnodium fuliginodes</i>
	<i>Limacinia concinna</i>	" <i>Cladosporium herbarum</i>
	" "	" <i>Capnodium fuliginodes</i>
	<i>Athaloderma ferruginea</i>	" " "
	" "	" <i>Cladosporium herbarum</i>
	<i>Penicillium expansum</i>	" " "
	" "	" <i>Penicillium expansum</i>
	<i>Capnodium anonas</i>	" <i>Cladosporium herbarum</i>
	" "	" <i>Capnodium Walteri</i>
	" "	" <i>Capnodium fuliginodes</i>
	" "	" <i>Dematium pullulans</i>
	" "	" <i>Caldariomyces</i> sp. 1
	" "	" <i>Capnodium salicinum</i> var. <i>uniseptatum</i>
	<i>Chaetothyrum cinereum</i>	" <i>Dematium pullulans</i>
	<i>Microxyphium</i> sp. 1	" <i>Capnodium fuliginodes</i>
	" " "	" <i>Capnodium salicinum</i> var. <i>uniseptatum</i>
	" " "	" <i>Microxyphium</i> sp. 1
	" " "	" <i>Capnodium Walteri</i>
	<i>Cladosporium herbarum</i>	" <i>Dematium pullulans</i>
	" "	" <i>Capnodium salicinum</i> var. <i>uniseptatum</i>
	" "	" <i>Triposporium</i> sp.

<i>Dematium pullulans</i>		„ <i>Capnodium Walteri</i>
„ „		„ <i>Dematium pullulans</i>
Class 5b.	A	B
<i>Caldariomyces</i> sp. 1		and <i>Dematium pullulans</i>
„ „ „		„ <i>Limacinia concinna</i>
„ „ „		„ <i>Capnodium Walteri</i>
„ „ „		„ <i>Aithaloderma ferruginea</i>
„ „ „		„ <i>Triposporium</i> sp.
„ „ „		„ <i>Capnodium salicinum</i> var. <i>uniseptatum</i>
„ „ „		„ <i>Caldariomyces</i> sp. 1
„ „ „		„ <i>Microxyphium</i> sp. 1
„ „ „		„ <i>Capnodium fuliginodes</i>
„ „ „		„ <i>Cladosporium herbarum</i>
<i>Dematium pullulans</i>		„ <i>Triposporium</i> sp.
„ „		„ <i>Capnodium fuliginodes</i>
„ „		„ <i>Capnodium salicinum</i> var. <i>uniseptatum</i>
<i>Triposporium</i> „p.		„ <i>Aithaloderma ferruginea</i>
„ „		„ <i>Capnodium fuliginodes</i>
<i>Limacinia concinna</i>		„ <i>Capnodium salicinum</i> var. <i>uniseptatum</i>
<i>Capnodium fuliginodes</i>		„ <i>Chaetothyrus cinereum</i>
„ „		„ <i>Capnodium salicinum</i> var. <i>uniseptatum</i>
Class 6.	A	B
<i>Limacinia concinna</i>		and <i>Cladosporium herbarum</i>
<i>Capnodium Walteri</i>		„ <i>Dematium pullulans</i>
<i>Chaetothyrus cinereum</i>		„ <i>Cladosporium herbarum</i>
<i>Capnodium ananæ</i>		„ „ „

From this it can be seen that the majority of sooty-mould fungi cause only slight stalling effects on each other. *Caldariomyces* sp. 1 and *Microxyphium* sp. 1 cause more stalling than any other species.

Plate iii, figure 2, shows a colony of *Cladosporium* growing over a colony of *Capnodium ananæ* (Class 6). There appears to have been little or no slowing down of the growth rate of either fungus.

Plate iii, figure 3, shows an example of slight stalling. The growth rate of both fungi, *Caldariomyces* sp. 1 and *Limacinia concinna*, has been slowed slightly in the adjacent parts of the colonies (Class 5a). A slightly greater degree of stalling is shown in Plate iii, figures 4 and 5. In Plate iii, figure 4, *Capnodium fuliginodes* and *Caldariomyces* sp. 1 are shown causing fairly strong mutual slowing in adjacent parts of the colonies. In Plate iii, figure 5, *Capnodium Walteri* and *Caldariomyces* show a similar effect (Class 5b).

An example of stronger stalling is shown in Plate iii, figure 6, representative of Class 4. Growth has almost entirely ceased in adjacent parts of the colonies.

In Plate iii, figure 7a, is shown an example of Class 3. *Limacinia concinna* has caused the growth of *Penicillium expansum* to cease abruptly. Plate iii, figure 7b, shows the same colonies two weeks later. It can be seen that the *Penicillium* colony has not grown round the *Limacinia* colony to any extent. The *Limacinia* colony, on the other hand, has continued to enlarge and is growing over the edge of the *Penicillium* colony, but at a slightly slower rate than at the edge farthest from it.

It is apparent that *Penicillium* is fairly strongly affected by the growth of most sooty-mould fungi. *Cladosporium* is scarcely affected by the growth of the members of the Capnodiaceae, *Dematium* is affected by some, but not at all by others.

Since stalling is a function of the medium, it is not possible to assume from their behaviour on potato glucose agar that the fungi will behave similarly on "honey dew".

Consequently a representative group of fungi comprising some found to be mutually staling, slightly staling and not staling on potato glucose agar, were grown on agar of the composition 2% unpurified adonite, 2% agar.

The results showed that mutual retardation of growth by sooty-mould species on unpurified adonite is less marked than on potato glucose agar. Members of the Capnodiaceae show little or no sign of mutual effect (Class 6, Plate iii, fig. 8, *Capnodium fuliginodes* and *Triposporium* sp.; Plate iii, fig. 9, *Capnodium fuliginodes* and *Chaetothyrium cinereum*). Only those species which show the strongest effects (Class 5b) on potato glucose agar show slight retarding effects (Class 5a) on adonite agar. The growth of *Penicillium* is retarded more or less strongly by sooty-mould fungi on adonite agar.

#### CONCLUSIONS.

The distribution of each species of sooty-mould fungus appears to be dependent on one or more factors. All the fungi occurring together in similar positions are not limited to them for the same reasons. *Capnodium salicinum*, *C. Walteri* and, to a less extent, *C. anonae* are resistant both to heat and desiccation, and in nature occupy the most exposed habitats. *Iimacinia*, *Aithaloderma* and *Microxyphium* sp. 1 are limited to favourable habitats by susceptibility both to heat and desiccation. The members of the Chaetothyriaceae, *Triposporium* and *Trichopeltis*, though strongly resistant to heat, are restricted to moist localities by their susceptibility to desiccation.

*Capnodium elegans*, *C. mucronatum* and *C. moniliforme* form a group by themselves, since they are resistant both to heat and desiccation, yet in nature occur in rain-forest areas only. Either they may be restricted to the excretions of certain specific scale insects of limited distribution, or they may require a very moist atmosphere for growth. These species could not be obtained in culture and, therefore, experiments could not be made to test the hypotheses.

Heat and desiccation appear to be the most important factors influencing the distribution of sooty-mould species in nature, cold evidently having no effect.

The results of the tests on the heat-resisting and desiccation-resisting powers of sooty-mould species in culture largely confirm those obtained for naturally-occurring material. Several species are, however, more resistant both to heat and to desiccation in culture than in nature. It appears probable that the factors for resistance are specific to each fungus species. It appears also from the experiments that the composition of the media in which the fungi are grown may considerably modify their powers of resistance both to heat and to desiccation.

True sooty-mould fungi are able to withstand very considerable temperatures in the dry condition but are killed quickly by exposure to moist heat. This has also been found to be the case with certain wood-destroying fungi by Snell (1923), and is known to be the case with lichens (see Smith, 1921).

It seems reasonable to assume that when growing on excretions of *Ceroplastes destructor* most true sooty-mould fungi do not form staling substances in sufficient quantities to retard each other's growth noticeably. Since the sooty-mould fungi do produce staling substances which retard the growth of *Penicillium* strongly, it seems probable that a colony of sooty-moulds, once established, could prevent to some extent the growth of *Penicillium* in it.

It also appears likely that some of the Capnodiaceae could not invade a sooty-mould colony in which *Dematium* is well established, but many species, such as *Capnodium anonae*, could do so without difficulty.

Several species of sooty-moulds have been found to be mutually antagonistic in culture, notably *Caldariomyces* sp. 1 and *Microxyphium* sp. 1, and these have not been found associated in nature. Some species, therefore, which belong to the same ecological class, may not occur together because of their mutually antagonistic effect.

The relative paucity of the common saprophytic moulds, of which *Penicillium expansum* has been taken as the type, appears to be due to a number of causes. The chief of these is probably their inability to withstand high temperatures and prolonged desiccation. Another cause may be that the composition of the food material available is not specially suitable for their growth. Finally it appears that the staling substances produced by the true sooty-mould fungi have a retarding effect on their growth. This effect may be lessened during periods of wet weather, since the staling substances would be likely to be washed out of the mould. Actually it has been found that *Penicillium* spp., *Alternaria* spp., *Fusarium* spp., etc., are most abundant in sooty-mould colonies in wet weather, and while this is probably largely due to the absence of strong evaporation, it may in part be due to the absence of staling substances.

The limitation of most sooty-mould-forming species in nature to the excretions of scale insects appears to be due to their extremely slow growth rate. Sooty-moulds appear to be specially adapted to an epiphytic life on account of their ability to withstand heat and dryness, and to grow slowly, making use of any slight amount of water available for this purpose.

It has been found by Zeller and Schmitz (1919), Asthana and Hawker (1936), Mix (1933), and others, that the growth substances produced by a fungus in culture may have the effect of increasing the sporulation of other species as well as retarding their growth. This effect has been observed in mixed cultures of sooty-mould fungi, and may be one of the reasons why, in nature, sooty-mould fungi are mostly found in a fruiting condition. Another factor which is probably of importance in this connection is the ultra-violet radiation of sunlight. Ramsey and Bailey (1930), Stevens (1928), and others, have found that ultra-violet radiation increases sporulation in fungi.

#### SUMMARY.

In nature sooty-mould fungi grow very slowly, as they can grow only during periods of damp weather. They store up an oil-like substance, which is drawn upon when growth is made.

Associations of sooty-mould fungi characteristic of certain habitats are described.

The powers of resistance to heat, cold and desiccation shown by a number of species are recorded, and their bearing on the distribution of the fungi in nature is discussed.

The influence of different types and different concentrations of culture media on the powers of resistance to heat and desiccation of sooty-mould fungi grown in culture is described.

Adonite, the chief constituent of the "honey dew" of *Ceroplastes destructor*, is very suitable for the growth of most sooty-mould fungi. It is not specially suitable for the growth of *Penicillium*. Unpurified adonite of scale-insect origin is more suitable for the growth of sooty-mould fungi than purified adonite of plant origin.

Most true sooty-mould fungi do not stale potato glucose agar to any great extent for their own growth. *Caldariomyces* sp. 1 and *Microxyphium* sp. 1 cause

the greatest amount of staling, *Capnodium anonae* the least. On unpurified adonite agar, staling is even less marked than on potato glucose agar.

Substances are produced by sooty-mould fungi in both media which retard the growth of *Penicillium* fairly strongly. Some species retard the growth of *Dematium* also.

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#### DESCRIPTION OF PLATE III.

Fig. 1.—Leaves of *Cryptocarya glaucescens* showing colonies of *Chaetothyrium fusisporum* (A) and *C. roseosporum* (B).  $\times 0.56$ .

Fig. 2.—Colonies of *Capnodium anonae* (A) and *Cladosporium* (B) showing no mutual antagonism.  $\times 0.8$ .

Fig. 3.—Colonies of *Caldariomyces* sp. 1 (A) and *Limacina concinna* (B) showing slight mutual antagonism.  $\times 0.8$ .

Fig. 4.—Colonies of *Capnodium fuliginodes* (A) and *Caldariomyces* sp. 1 (B) showing fairly strong mutual antagonism.  $\times 0.8$ .

Fig. 5.—Colonies of *Caldariomyces* sp. 1 (A) and *Capnodium Walteri* (B) showing fairly strong mutual antagonism.  $\times 0.8$ .

Fig. 6.—Colonies of *Caldariomyces* sp. 1 (A) and *Capnodium salicinum* var. *uniseptatum* (B) showing strong mutual antagonism.  $\times 0.8$ .

Fig. 7a.—A colony of *Penicillium expansum* (B) whose growth has been checked by the growth of a colony of *Limacina concinna* (A).  $\times 0.8$ .

Fig. 7b.—The same colonies two weeks later showing that the colony of *Limacina concinna* has continued to grow and that the colony of *Penicillium expansum* has remained almost stationary.  $\times 0.8$ .

Fig. 8.—Colonies of *Triposporium* sp. (A) and *Capnodium fuliginodes* (B) showing no mutual antagonism on unpurified adonite agar.  $\times 0.8$ .

Fig. 9.—Colonies of *Chaetothyrium cinereum* (A) and *Capnodium fuliginodes* (B) showing no mutual antagonism on unpurified adonite agar.  $\times 0.8$ .

# ON THE HISTOLOGICAL STRUCTURE OF SOME AUSTRALIAN GALLS.

By E. KÜSTER, Hon. F.R.M.S. (London), Professor of Botany, Giessen (Germany).

(Fourteen Text-figures.)

[Read 28th April, 1937.]

The galls of the Australian flora have been often subjected to detailed investigations—from Schrader (1863) and Rübsaamen (1894) to numerous studies of Froggatt.

The interest taken in the Australian galls is founded not only on the novelty of the objects, which promise a great many details yet undiscovered, compared with the relatively well investigated European and North American galls. In addition to the descriptive studies and catalogues there are important points of view of general biology: the botanist is interested in the Australian galls because they are associated with host-plants different from those in the European and North American floras; the zoologist confirms that Coccidae are responsible for a great part of the Australian galls, but these play an unimportant part in the northern hemisphere.

The general cecidology has developed through the study of the galls of the European flora. The Cynipid galls of *Quercus* have made known a great many highly complicated morphological and histological differentiations which cannot be attained by the productions of other gall-making insects in Europe or in North America, and they overshadow the productions of other host-plants of the Hymenoptera through their variety of structure. Therefore we have long been accustomed to consider the Cynipid gall of *Quercus* as the chief object of the general cecidology.

The questions which concern the botanist have hardly been considered in connection with the Australian Eucalyptus galls. The botanical communications are hardly more than descriptions of the exterior form of the galls. Consideration of the cytological and histological structure of the galls is completely wanting, although most important results can be expected from their investigation.

Some results which concern the anatomy of the Australian galls are described herewith, although I know very well that distance hinders me from detailed investigation of living and ontogenetic material, and so I can only touch on many important questions.

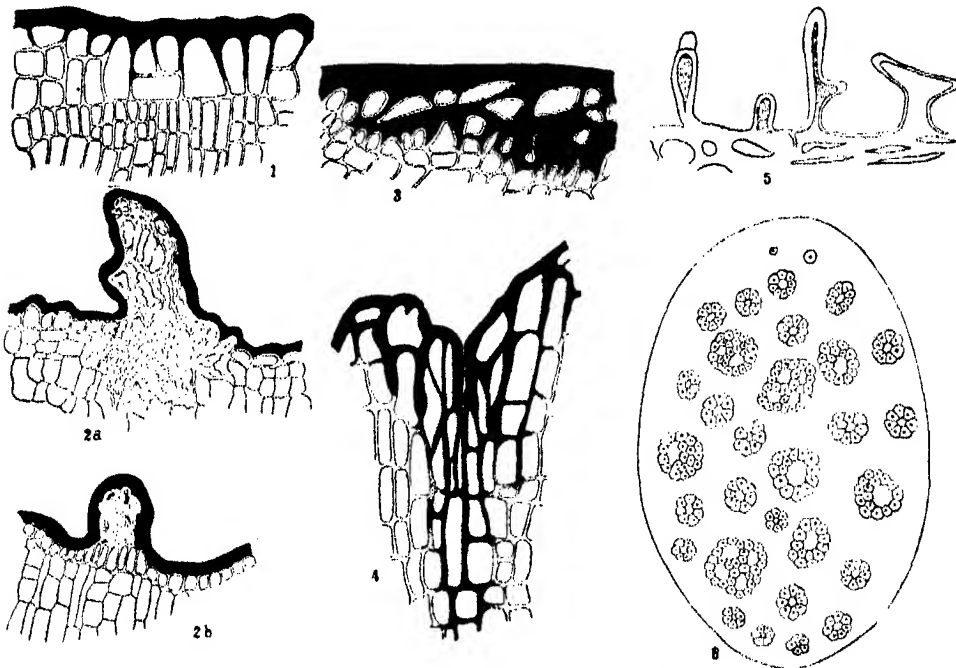
A great many of the galls which I have studied belong to Coccidae. These productions are not inferior to the highly organized productions of Cynipidae, either in exterior form or in histological structure. The histological structure of the galls of Coccidae promises important and surprising results, and so I should like to recommend its study very strongly to Australian cecidologists and phytopathologists.

The following pages perhaps give a few suggestions for future detailed investigations.

*Epidermis.*

In the "inclosed" galls, i.e., in those whose epidermis develops ontogenetically directly from the epidermis of the mother organ, the epidermis is usually equal or very similar to the normal tissue. Noteworthy is often the strong upward growth of the cells, so that they take the form of narrow palisades; it sometimes happens that palisades divide themselves by pericline walls and the epidermis becomes locally a double or multiple layer; figure 1 shows part of a gall, in which the cells of the epidermis are highly developed and grow as a cushion in the fundamental tissue. Such features are not common in galls.

The cuticle of many foliar galls is much thicker than the normal one. On concavely curved divisions of a coccid gall I noticed the formation of folds of the surface: there are narrow ridges consisting either of folded epidermis matter rising from the fundamental tissue (Fig. 2a) or simply of cuticle which here and there frees itself from the epidermis cells and rises in folds; under the cuticle one sees small remains of membrane, lower still the epidermis (Fig. 2b).



"Cuticularepithel" (Damm) has been observed sometimes in the galls (Küster). Especially strong, many-layered and varying, I have found it in many Coccid galls of the eucalypts; particularly near small wounds, but apparently also independent of such, the upper layer of fundamental tissue is cutinized; the cells become similar to the epidermis so that one seems to see two typical and strongly cutinized epidermis layers; also the third and fourth tissue layer may be cutinized (Fig. 3).

An unusual form of "cuticularepithel" I have found in those leaf galls in which the growth of the fundamental tissue is impeded here and there—perhaps

through a small trauma—and a deep notch in the cushion of the gall tissue. In the surface of the gall tissue brought together one finds a cuticular-epithel in further development (Fig. 4).

Free galls, i.e., such as develop from the interior of the mother and whose epidermis may be considered as a new formation, do not seem to be lacking in the Coccid galls of eucalypts. It seems impossible to work on this important question without ontogenetic material. I recommend this problem for detailed studies.

In galls which I supposed to be free, I have repeatedly noticed luxurious cork formation in the physiological trauma of the point of rupture.

In comparison with the *Quercus* galls and many other features of the European gall flora, I mention that the Eucalypt galls are smooth; only in one gall have I observed uni- or pluricellular, simple or rarely T-shaped, branched albuminous hairs, developed on the interior surface. I am unable to say whether they arise from a typical epidermis or from a fundamental tissue-like matter whose surface cells sometimes stretch themselves tube-like (Fig. 5).

#### Bundles.

In many Eucalyptus galls the bundles have the same loose net-like distribution which is well known from the *Pontania* galls and many Cynipidae productions of the European flora. I have nothing remarkable to report on the structure of the delicate bundles as I have found them in many Australian galls.

In several Coccid galls the development of highly differentiated and characteristically distributed bundles is surprising.

As first example, I mention the bundles of the long processes of the well-known gall of *Brachyscelis munita*. In the cross section (Fig. 6) there are about 40 bundles regularly distributed and parallel to one another; one finds large bundles next to small ones, single ones next to small groups composed of 2-4 bundles. The distribution is somewhat similar to the structure of monocotyledonous stems; however, the frequent very striking accumulation of the bundles in the periphery is lacking.

The structure of the single bundles is characterized by the collateral distribution of xylem and phloem; it is difficult to determine whether small phloem divisions exist, corresponding to the intra-xylary phloem of the Myrtaceae and to the structure of the bicollateral bundles; the bundles are too small; one can, however, definitely say that sometimes isolated groups of phloem-like cells are to be found (Fig. 7) between the sclerenchyma.

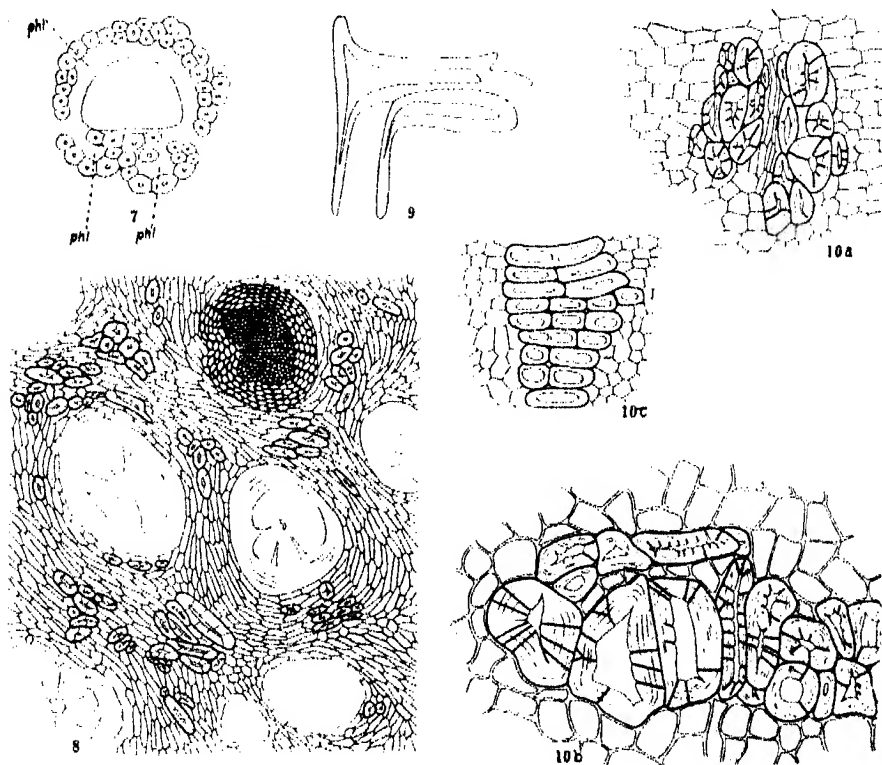
The orientation of the phloem is not determined by that of the bundles in the cross-section of the gall-organs; the phloem is not always orientated outwards. But when several bundles unite in a small group, the phloem of the single bundle is always orientated toward the periphery of the small group.

All bundles are enveloped by bast fibres (Fig. 6). These form a ring, mostly uninterrupted round the bundles, and sometimes enclose also the above-mentioned isolated phloem-like groups (Fig. 7). The bast-fibre shoot is generally one cell-layer thick; more rarely one finds two or three layers.

When the bundles unite in groups in this way, so that they touch one another, and when no fundamental tissue layers remain between them, the bundle tissues are divided from the bast-fibre layers in 2, 3 or 4 compartments; sometimes the division remains incomplete, in which case one sees a bast-fibre septum push itself only as far as the centre of the bundle tissue.



As second example, I take the bundles of a gall which is similar to (or identical with) the gall of *Brachysectis conica*. In the urn-shaped body of the galls, several centimetres long, numerous bundles are to be seen. These are remarkable because of their richness in secondary tissues; they form radially-structured concentric or excentric masses, which enclose in the centre of growth a very small, perhaps phloem-like, cell-group. The wood-cylinder consists especially of cells arranged in regular radial rows, and is streaked by pith rays (Fig. 8). In the largest bundles the longest radii are about 20 cells long; it is difficult to demonstrate phloem beyond the xylem cylinder; in many cases the outside xylem cells touch directly fundamental tissue cells, in others a thin layer of a phloem-like tissue is to be seen. To describe the ontogeny of the bundles was impossible with my material; especially I was not able to decide whether, in the phase before me, the bundles had everywhere finished the production of secondary tissue or not.



The histological structure of these bundles is characterized in the first place by the regular radial distribution of the elements. There are found the characteristics well known in many other wound-wood and gall-wood features (in wood = knots and "Kugeltrieben"; Küster, 1925). Sometimes a difference is seen between thin-walled exterior and thick-walled interior cells between which an annular ring-like boundary line is noticed. In many other cases, single broad

or narrow sectors are differentiated from the greater part of the bundles by their structure orientating their elements, not in the longitudinal axes of the bundles, but perpendicular to them.

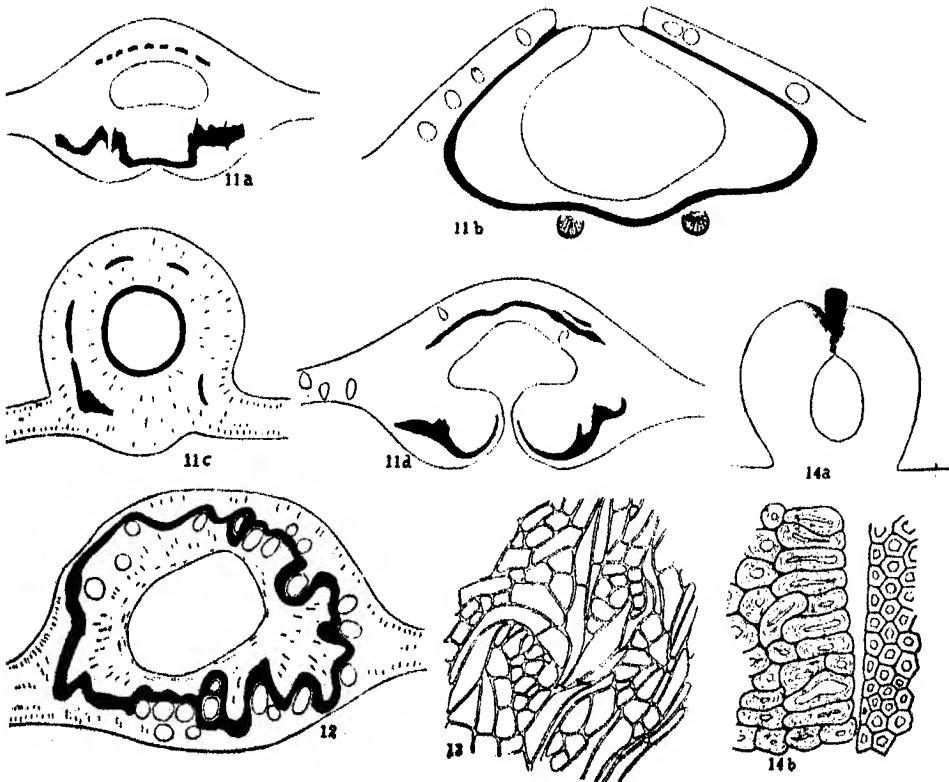
If the thickening of the bundles is anywhere impeded, contours of the wood-body arise as they are known from the carcinoma features of the trees.

Every bundle which is capable of such strong growth may be considered a small stele. This form of anomalous thickening is unknown to me in other galls.

#### Stone cells.

As with the galls of many Diptera and Hymenoptera, also many of the Coccid galls are very rich in stone cells.

As in those, we find also in Coccid galls stone cells of various forms and wall qualities—relatively thin and thick-walled, thickened on all or one side. Stone cells of the second species are known to the European and American cecidologists, particularly from very numerous oak galls (Weidel), also from *Salix* and other galls (Küster). An ontogenetic examination of the stone cells of the Eucalypt galls from Weidel's point of view is greatly to be desired. I was not able to determine from the material before me whether all galls provided with stone cells thickened on one side are produced by Coccids; perhaps some of them were produced by Cynipids; in any case, it is certain that stone cells thickened on one side occur also in Coccid galls.



I repeatedly noticed in Eucalypt galls stone cells, which were spherical or palisade-like, formed and at some points were provided with long thread-like processes (Fig. 9). It has been long known from normal and pathological anatomy that stone cells push between neighbouring cells with pointed thorn-like forms; the Australian specimens here in question were noticeable to me as the processes developed in the direction perpendicular to the surface of the gall-bearing organ and towards the strongest normal tissue growth.

Very striking is the circumstance in many Eucalypt galls, that in transverse and longitudinal section the stone cells form round-contoured or spindle-like groups (Fig. 10); there is no doubt that the cells united in a group are descendants of one mother-cell.

The distribution of the stone cells in the tissues of the Coccid galls follows the principle well known from many other anatomically carefully investigated galls: either the stone cells are singly placed or united in small groups in the thin-walled fundamental tissue or they form continuous zones ("mechanische Mäntel") in the later phases of the cecidogenesis. One often sees thin-walled fundamental tissue become somewhat thick walled and equally lignified.

Figure 11 shows some Coccid galls and their mechanical zones. From the ontogenetic point of view, especially interesting are the galls in which the larva-cavities are surrounded by abundant thin-walled tissue and the exterior layers are formed of parenchyma filled with oil receptacles. The stone-cell zones develop at the junction between the exterior and interior parenchyma; noteworthy features result, if an exaggerated growth of the exterior parenchyma compels the contour of the mechanical zone to rupture or "Verwerfung" (Fig. 11a).

In some galls oil receptacles are found only beyond the thick-walled zones and are very closely accumulated; the mechanical tissue layers push themselves here and there between neighbouring oil receptacles and can enclose these imperfectly (Fig. 12).

#### *Oil Receptacles.*

To the most important anatomical characters of *Eucalyptus* belong the oil receptacles. They play a large part in the galls of *Eucalyptus*. I have earlier (Küster, 1900) demonstrated that the Eucalypt galls are differentiated greatly through the richness of their oil receptacles: I found galls containing only a few receptacles or completely lacking in them—to the latter belong several foliar galls of *Eucalyptus* which remind one, through the production of "emergences", of the "Erineum populinum" among others, and which may be considered through their morphological characters—merely as conjecture—as mite galls.

The size of the oil receptacles in galls often exceeds the normal. I saw, in some Coccid galls, receptacles of which the diameter was  $380\mu$ ; in oval receptacles the longest diameter was even  $540\mu$ . On the other hand, one also meets extraordinary small receptacles in Eucalypt galls, and in some others large and small ones irregularly mixed. An ontogenetic examination, particularly of the small receptacles, would certainly be of great interest and promises various noteworthy additions to Fohn's results.

The position of the oil receptacles varies. I have found galls in which all layers show receptacles, so that they lay, in some parts, in 6-8 layers. I found others in which the receptacles are to be seen directly beneath the epidermis and sometimes push it out hemispherically. Sometimes the receptacles lay so compactly that only narrow tissue remains lay between them.

The histology of the oil receptacles of *Eucalyptus* galls shows various notable features. Their form is sometimes determined by the growth in the neighbourhood; between exceptionally elongated cells the receptacles assume a form in the same direction extended, sometimes like a bottle-neck. The cells of the epithelium are often very large and arched; they fill the lumina of the receptacles with ball- or tube-like forms. It would be very important to examine the physiology of those receptacles whose epithelium has become thick walled. I have never noticed sclerosis, pits, lignification in the cells of the epithelium; in one of the galls which I examined, the tissue surrounding the receptacles so perfectly devolved on sclerosis that the receptacles were almost completely enclosed by thick-walled lignified tissue (Fig. 12); however, the cells directly enveloping the lumina of the receptacles (epithelium) take no part in the sclerosis.

The great abundance of receptacles in many galls suggests the importance of a comparative chemical examination of the oil which is produced in the galls and in the normal leaves of *Eucalyptus* (cf. Salgues, 1936).

#### *Secondary tissues.*

Voluminous masses of secondary tissues develop through the gall infection out of the normal cambium ring of the stems. The abnormal wood forms thick layers, the structure of which equals that of other gall-wood features and is characterized especially by the shortness of its elements. Figure 13 shows a longitudinal section of the secondary gall wood. A great part of the wood consists of thick-walled parenchyma, between which run short fibre-like elements—sometimes straight, sometimes curved, rarely fork-like branched.

Also secondary phloem is formed abundantly through some gall infections; sometimes I was struck by the very clear stratification; I counted 14 layers of stone cells which alternated with thin-walled phloem.

Cork patches and spherical cork nests occur in the galls, as in the normal *Eucalyptus* organs, after local necrosis and local trauma.

#### *Necrosis; cytolysis.*

Dry necrosis is in some galls the result of interior suberization, through which the outward layers of gall tissues die off. Occasionally the symptoms of the dry necrosis become especially interesting through position and form and through the histological metamorphosis of the dying tissue divisions and the neighbouring layers. Figure 14 shows in the vertex of the gall a stopper-like necrotic part whose cells are very thick walled; the directly adjacent layer consists of long palisade-like cells.

Lignification of tissues is by no means rare in galls (Lysenchyma—Weidel, Küster). In the galls of *Eucalyptus* one meets symptoms of lignification or cytolysis very often. The cytolysis does not characterize fixed phases of the gall evolution or fixed tissues; rather, one often sees small groups of primary and of secondary gall tissues dead and lignified—similar to the case of the gummosis. Detailed examination of the phenomena seems very desirable.

I am indebted to Miss Fawcett, of Melbourne, for the opportunity to examine a great number of Australian *Eucalyptus* galls. I offer her my best thanks for her kind assistance; she has sent me countless well preserved samples.

The above comments give a report on my investigation of the material provided by Miss Fawcett. I publish them in the hope of giving my Australian colleagues suggestions for more careful investigation of the galls of Australia which have hardly been considered botanically.

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## FINAL ADDITIONS TO THE FLORA OF THE COMBOYNE PLATEAU.

By E. C. CHISHOLM, M.B., Ch.M.

[Read 28th April, 1937.]

In These PROCEEDINGS (1925, p. 284, 1927, p. 378, and 1934, p. 143) the writer has previously recorded the Flora found on the Comboyne Plateau with notes on the species. This final paper is a continuation of his observations, bringing the record up to the middle of 1935.

## CRYPTOGAMAE VASCULARES.

## FILICALES.

## HYMENOPHYLLACEAE.

*Hymenophyllum australe* Willd.—A small fern found growing on rocks in close proximity to water and often in association with moss. The stems and branches are flanged. It does not appear to be very plentiful.

*Hymenophyllum tunbridgense* (L.) Smith.—Found growing on rocks near running water; distinguished by the stems and branches being cylindrical without flanges. It grows generally in association with moss.

## POLYPODIACEAE.

*Dryopteris queenslandica* Domin. (= *Baileyi* Maid. and Betcher).—An inhabitant of the floor of the brushes. It closely resembles *D. decomposita* and *D. acuminata*, though the pinnules are broader. It has a creeping rhizome, but no indusium, which distinguishes it from the other two species.

*Diplazium japonicum* (Thunb.) Bedd.—A small fern usually found near running water. A fertile frond is very characteristic. The sori are arranged in diagonal lines; a row on each side of the midrib of the pinnule, and whitish in colour.

*Cheilanthes tenuifolia* Sw.—Not common. Found in dry situations on mountain slopes growing on rocks, occasionally in the company of *Notholaena distans*.

*Adiantum diaphanum* Bl.—A maiden hair not often seen. It seems to prefer the vicinity of water, and is found growing in association with other ferns.

*Pteris umbrosa* R.Br.—A tall fern and found in only one or two places, growing on hillsides in the brushes.

*Asplenium flaccidum* Forst.—A rare form growing in damp situations.

## ANGIOSPERMAE.

## MONOCOTYLEDONEAE.

## CYPERACEAE.

*Lepidosperma laterale* R.Br.—One of the larger sedges, not very common, and found in cleared land in hilly situations.

*Carex appressa* R.Br.—Grows mostly about low-lying land and often along the course of creeks. Fairly common in these localities.

*Carex longifolia* R.Br.—This species seems to prefer cleared land on higher elevations, where it is plentiful.

## COMMELINACEAE.

*Anellema acuminatum* R.Br.—An inhabitant of the brushes, noticed particularly in the Government Forest Reserve near the Rawson Falls. It does not appear to be plentiful.

## DIOSCOREACEAE.

*Dioscorea transversa* R.Br.—A climber growing at the borders of the brushes on a mixed formation. It has shield-shaped leaves and hop-like fruit.

## ORCHIDACEAE.

*Liparis reflexa* Lindl.—A yellow orchid resembling a *Dendrobium*, growing on rocks in the vicinity of water. Found in association with *Dendrobium Kingianum*.

*Caladenia carnea* R.Br.—A very uncommon orchid found on sandstone formation and only seen on the eastern side of the Plateau.

## DICOTYLEDONEAE.

## PIPERACEAE.

*Piper hederaceum* A. Cunn.—A climber festooning high trees. It has a large palmate, fleshy leaf and is often met with in the brushes.

## URTICACEAE.

*Elatostemma reticulata* Wedd.—A low-growing plant with a large fleshy reticulate leaf growing on rocky formations in damp situations in the close vicinity of running water.

*Elatostemma stipitata* Wedd.—This has a smaller leaf growing in the same situations as the previous species and often in association with it.

## LORANTHACEAE.

*Viscum articulatum* Burm.—A mistletoe not often seen. Found on top of a range growing on *Cryptocarya Meissneri*.

## MENISPERMACEAE.

*Sarcopetalum Harveyanum* F.v.M.—Found growing in brush at the edge of clearings. It is of low growth, climbing over shrubby plants.

*Stephania hernandifolia* Walp.—This is also a climber; on superficial inspection it is very like the previous species and is found in the same kind of situations. The distinguishing feature is the peltately arranged stalk in this species, while in *S. Harveyanum* the stalk joins the leaf at the hilus close to the edge.

## LAURACEAE.

*Endiandra Sieberi* Nees.—This tree is rather uncommon, and instead of being widely branching, as it is on the sandstone of the coast, and moderately small, it makes its growth upwards, becoming a tall tree in the brushes with small canopy. It has a very cork-like bark, and the pale timber is of good quality.

## SAXIFRAGACEAE.

*Abrophyllum ornans* Hook.—A small tree with a leaf like a *Hydrangea*. It seems to prefer the vicinity of water. Not often seen.

## LEGUMINOSAE.

*Castanospermum australe* A. Cunn. Black Bean.—The writer has had an authentic account of this tree growing on both banks at the head of Thone Creek.

as late as nine years ago, when it was felled and burnt. Although it grew here in clumps, it seems to have been restricted to the one locality, as nowhere else on the Comboyne has it been known to occur. This is a very handsome tree yielding very valuable timber.

*Hovea acutifolia* A. Cunn.—A plant growing to 3 or 4 feet high and liking the neighbourhood of creeks. Found growing in a brush having leaves resembling *Lasiopetalum* in some of its species.

#### EUPHORBIACEAE.

*Phyllanthus gasstroemii* J. Muell.—Not often seen; the flower and fruit hang under the leaves, the fruit resembling a miniature tomato.

#### VITACEAE.

*Vitis clematidea* F.v.M.—This is not a common grape and is only found occasionally. It does not appear to attain large dimensions as do some of its congeners. Found mostly climbing over shrubs or small trees.

*Cayratia japonica* (Thunb.) Gagnepain.—This is a very rare form here, and was only found once. It festoons medium-sized trees and is a very graceful vine. The leaves are large and shining. It flowers and fruits at the same time, in March, April and May, though in May the flowering is finished. The crushed leaf has a nasty smell. It keeps and carries badly if not preserved in some way. In a few days, as it dries, it disintegrates, the leaves, flowers, and fruits all falling off the branches, and the small twigs, too.

*Cayratia* sp.—This appears to have a very restricted range, being found plentifully in the Rawson Forest Reserve on the west of the Plateau, but seen rarely elsewhere. It seems to be fairly closely related to *C. japonica*, though quite distinct specifically. It is a scabrous form, the stems, pedicels and main veins of the leaves, especially on the underside, being very hairy. It is of large growth, climbing to the tops of tall brush trees, the stem attaining at the base a diameter of about 3 inches. This is apparently a new species which, up to date, has not been identified with any known form.

#### ELAEOCARPACEAE.

*Sloanea austroqueenslandica* Domin.—Under the heading *S. Woollsi*, n. var. (These PROCEEDINGS, 1934, p. 150), the writer mentions this tree as probably a new variety, having a much larger area of dark wood than *S. Woollsi*. The bark of this species is also very much thicker and rougher, attaining a thickness of an inch at the height of a few feet from the ground in a tree of a diameter of 2 feet, whereas in *S. Woollsi* at the same distance from the ground in the same diameter of timber it is only about one-quarter of an inch. There is very little difference in either the fruits or leaves between the two species. If anything, the fruits of *S. austroqueenslandica* are slightly larger. This species remains longer while lying on the ground before it disintegrates, due to the small amount of white sap-wood.

#### PASSIFLORACEAE.

*Passiflora aurantia* G. Forst.—This is an exceedingly rare form here and only found in one locality amongst the secondary growth some years after the original brush had been cleared.

#### MYRTACEAE.

*Rhodomyrtus psidioides* Benth.—A brush tree, liking the vicinity of water, being found along the courses of creeks. Not very plentiful.



*Eucalyptus campanulata* Baker and Smith.—This Eucalypt was mentioned under the name of *E. Andrewsii* Maiden in the author's first paper (PROCEEDINGS, 1925, p. 291). Later investigation has shown that this species has, among other characters, the fruit more pyriform or bell-shaped than is the case with *E. Andrewsii*, whose fruit is more hemispherical. It differs also in bark.

*Eucalyptus triantha* Link.\*—According to the latest nomenclature, this name is synonymous with *E. acmenioides* Schau., which name it replaces. It is already dealt with under the latter name.

*Eucalyptus umbellata* (Gaertn.) Domin.\*—This name likewise replaces *E. tereticornis* Sm. for the same reason, and likewise dealt with before.

*Eucalyptus gummifera* Gaertn.\*—Replaces *E. corymbosa* Sm. under similar conditions.

*Kunzea corifolia* Reichb.—When the last paper was written the species of this form was undetermined, as it differed in some respects slightly from *K. corifolia*, but the difference was not enough to propose a variety for it. (See These PROCEEDINGS, 1934, pp. 151 and 155.)

#### ARALIACEAE.

*Tieghemopanax elegans* R. Viguier.—This is a rare species on the Plateau, and has only been seen twice. It is an inhabitant of the brush forests.

*Aratia cephalobotrys* F.v.M.—A creeping form found on the floor of the brushes, especially in the neighbourhood of running water. Not very often seen.

#### UMBELLIFERAE.

*Hydrocotyle hirta* R.Br.—A low-creeping species, liking damp situations and fairly plentiful. The leaf is large, hairy, and divided into lobes somewhat resembling the leaf of *Geranium dissectum*, though the divisions are not so fine.

*Hydrocotyle geraniifolia* F.v.M.—Found in the same situations and having the same running habit as the preceding species. The leaf is divided into five distinct narrow leaflets, each of which is deeply dissected. It does not appear to be common.

#### EPACRIDACEAE.

*Styphelia lanceolata* Sm. (*Leucopogon lanceolatus* R.Br.).—Very rarely seen and only found by the writer on the eastern side of the Plateau. It is one of the "whitebeards".

#### MYRSINACEAE.

*Rapanea Howittiana* Mez.—A fairly common inhabitant of the brushes. It appears to be a tree attaining no great height. It has a shiny stiff leaf of a light green colour, the edge being entire. The small flowers encircle the medium-sized twigs.

*Embelia australasica* Mez.—A climbing plant found in the brushes, with a stiff, shiny Eugenia-like leaf. Fairly plentiful.

#### EBENACEAE.

*Diospyros pentamera* F.v.M.—A tall tree with very dark, almost black, bark growing in the brushes but not common. Has small leaves, shaped like *Cryptocarya Meissneri*, the underside of which is yellow. It has a slender trunk for the height of the tree.

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\* "A Key to the Eucalypts", W. F. Blakely, 1934.

## OLEACEAE.

*Olea paniculata* R.Br.—This tree grows in the brushes and appears to be uncommon and to attain to a fair height. It possesses a rather large leaf with lighter underside showing very reticulate veins, the upper surface being dark green and shiny. The stems are covered with small rounded whitish pustules.

## APOCYNACEAE.

*Parsonsia ventricosa* F.v.M.—A small climber with elongated shield-shaped leaves with entire edges, the stalks exuding a milky juice when broken. Not very plentiful.

## ASCLEPIADACEAE.

*Tylophora paniculata* R.Br.—A small climbing form, fairly plentiful. The leaf, which is entire, is sometimes deep purple underneath.

## SOLANACEAE.

*Physalis minima* L.—Both this species and *Ph. peruviana* share the name of "Cape Gooseberry", which is incorrect, as the former is a native and the latter was introduced from South America. This is a very common species found growing all over the Comboyne after the original brush had been cleared. It has a pretty yellow flower with a purple centre. It is edible and much used for jam making.

## SCROPHULARIACEAE.

*Veronica calycina* R.Br.—This is a very small plant running on the ground with a blue-bell flower and very dissected leaf. Not often seen.

## GESNERACEAE.

*Fieldia australis* A. Cunn.—A climbing and running growth inhabiting certain brushes, and especially to be noticed in the Government Reserve near Rawson Falls. The leaf is freely dissected and hairy; the undersurface has a white flannel-like appearance. It is found growing over the rocks and bases of the brush trees.

## COMPOSITAE.

*Siegesbeckia orientalis* L.—A plant growing very thickly in cultivated areas and a pest to the farmer. It grows to a height usually of 3 or 4 feet. The involucre bracts exude a sticky secretion, so that it adheres to clothing.

*Senecio amygdalifolius* F.v.M.—This is to be found growing in profusion in certain parts of the Plateau which have been partially cleared and often found in association with *S. dryadeus*. It has a larger yellow flower than the latter form, with a dentate leaf.

My thanks are due to Mr. W. F. Blakely, Miss Lillian Fraser, and Miss Alma Melvalne, for determination of plants, the last especially for that of the Ferns.

## REVISED LIST OF THE PLANTS OF THE COMBOYNE PLATEAU, 1935.

## PTERIDOPHYTES-FILICALES.

- Osmundaceae: *Todea barbara* (L.) Moore.  
 Gleicheniaceae: *Gleichenia circinata* Sw.; *G. flabellata* R.Br.  
 Hymenophyllaceae: *Trichomanes venosum* R.Br.; *Hymenophyllum australe* Willd.;  
*H. tunbridgensis* (L.) Smith.  
 Dicksoniaceae: *Culcita dubia* (R.Br.) Maxon.; *Dicksonia antarctica* Labill.; *Hypolepis punctata* (Thunb.) Mett.; *H. rugulosa* (Lab.) J. Sm.  
 Cyatheaceae: *Alsophila australis* R.Br.; *A. Leichhardtiana* F.v.M.

Polypodiaceae: *Davallia pyxidata* Cav.; *Arthropteris Beckleri* Mett.; *A. obliterata* (R.Br.) J. Sm.; *A. tenella* (Forst.) J. Sm.; *Pteridium aquilinum* (L.) Kuhn.; *Histiopteris incisa* (Thunb.) J. Sm.; *Pteris umbrosa* R.Br.; *P. tremula* R.Br.; *Adiantum aethiopicum* L.; *A. formosum* R.Br.; *A. diaphanum* Bl.; *A. hispidulum* Sw.; *A. affine* Willd.; *Pellaea falcata* R.Br.; *P. paradoxa* (R.Br.) Hk.; *Cheilanthes tenuifolia* (Burm.) Sw.; *Notholaena distans* R.Br.; *Dryopteris decomposita* (R.Br.) O. Kuntz; *D. acuminata* (Lowe) Watts; *D. queenslandica* Domin; *D. parasticta* (L.) O. Kuntz; *Athyrium umbrosum* (Ait.) Presl; *A. umbrosum* var. *aemidioides* E. C. Chisholm; *Diplazium japonicum* (Thunb.) Beddome; *Asplenium nidus* L.; *A. flabellifolium* Cav.; *A. adiantoides* (L.) C. Chr.; *A. flaccidum* Forst.; *Blechnum cartilagineum* Sw.; *B. serrulatum* Rich.; *B. Patersoni* (R.Br.) Mett.; *B. discolor* (Forst.) Keyserling; *B. capense* (L.) Schlecht.; *Doodia aspera* R.Br.; *Pleopeltis Brownii* Wickstr.; *P. diversifolia* (Willd.) (*Polypodium diversifolium* Willd.); *Cyclophorus serpens* (Forst.) C. Chr.; *C. confusus* (R.Br.) C. Chr.; *Platyterium bifurcatum* (Cav.) C. Chr. (*P. alaicorne* Desv.); *P. grande* (A. Cunn.) J. Sm.; *Polypodium Billardieri* (Willd.) C. Chr. (*P. australe* Mett.).

## PHANEROGAMAE-GYMNOSPERMAE.

## CYCADALES.

Cycadaceae: *Macrozamia Perowskiana* Miq.

## CONIFERAE.

Taxaceae: *Podocarpus elata* R.Br.

Pinaceae: *Callitris Macleayana* F.v.M.

## ANGIOSPERMAE-MONOCOTYLEDONEAE.

Typhaceae: *Typha angustifolia* Linn.

Potamogetonaceae: *Potamogeton tricaratus* F.v.M.

Cyperaceae: *Lepidosperma concavum* R.Br.; *L. laterale* R.Br.; *Gahnia aspera* Spreng.; *G. pelticorum* Labill.; *Carex brunnea* Thunb.; *C. appressa* R.Br.; *C. longifolia* R.Br.

Palmae: *Linosydeia monostachys* Wendl. & Prude; *Archontophoenix Cunninghamiana* Wendl. & Prude.

Araceae: *Typhonium Brownii* Schott.; *Colocasia macrorrhiza* Schott.; *Gymnostachys anceps* R.Br.; *Pothos longipes* Schott.

Flagellariaceae: *Flagellaria indica* L.

Commelinaceae: *Commelina cyanea* R.Br.; *Aneilema acuminata* R.Br.

Philydraceae: *Philydram lanuginosum* Banks.

Liliaceae: *Kreyssigia multiflora* Reicheb.; *Stypandra glauca* R.Br.; *Dianella coerulescens* Sims; *Xerotes longifolia* R.Br.; *Xanthorrhoea resinosa* Pers.; *Cordyline stricta* Endl.; *Drymophila Moorei* Baker; *Geitonoplesium cymosum* A. Cunn.; *Eustrephus latifolius* R.Br.; *Rhipogonum album* R.Br.; *Smilax glycyphylla* Sm.; *S. australis* R.Br.

Dioscoreaceae: *Dioscorea transversa* R.Br.

Iridaceae: *Libertia paniculata* Spreng.

Orchidaceae: *Liparis reflexa* Lindl.; *Dendrobium speciosum* Smth.; *D. Kingianum* Bidw.; *D. gracilicaule* F.v.M.; *D. pugioniforme* A. Cunn.; *D. teretifolium* R.Br.; *Bolbophyllum Shepherdi* F.v.M.; *Dipodium punctatum* R.Br.; *Spiranthes australis* Lindl.; *Diuris maculata* Sm.; *Microtis porrifolia* R.Br.; *Caladenia carnea* R.Br.

## DICOTYLEDONEAE.

Casuarineae: *Casuarina suberosa* Ott. & Dietr.; *C. torulosa* Ait.

Piperaceae: *Piper hederaceum* A. Cunn.

Fagaceae: *Fagus Moorei* F.v.M.

Ulmaceae: *Trema aspera* Blume (*T. cannabina* Lour.).

Moraceae: *Cudrania javanensis* Tréc.; *Ficus Henneana* Miq.; *F. eugenioides* F.v.M.; *Ficus rubiginosa* Desf.; *F. macrophylla* Desf.; *F. stephanocarpa* Warb.

Urticaceae: *Urtica incisa* Polr.; *Laportea gigas* Wedd.; *Elatostemma reticulata* Wedd.; *E. stipitata* Wedd.; *Australina pusilla* Gaud.

Proteaceae: *Persoonia media* R.Br.; *P. linearis* Andr.; *P. sp.*; *P. mollis* R.Br. var. ?; *Helicia glabriflora* F.v.M.; *Orites excelsa* R.Br.; *Hakea saligna* R.Br.; *Lomatia Fraseri* R.Br.; *Stenocarpus salignus* R.Br.; *Banksia spinulosa* Sm.

Santalaceae: *Ezooarpus cypressiformis* Labill.

Loranthaceae: *Phrygillanthus celastroides* Eichl. (*Loranthus celastroides* Sieb.); *Viscum articulatum* Burm.; *Loranthus dictyophlebus* F.v.M.; *L. pendulus* Sieb.

Polygonaceae: *Polygonum hydropiper* L.

Chenopodiaceae: *Chenopodium triangulare* R.Br.

Phytolaccaceae: *Codonocarpus attenuatus* Hook.

- Ranunculaceae: *Clematis aristata* R.Br.; *C. glycinoides* DC.; *Ranunculus lappaceus* Sm.; *R. rivularis* Banks & Solander.
- Menispermaceae: *Leptophora Moorei* Miers.; *Sarcopetalum Harveyanum* F.v.M.; *Stephania hernandifolia* Walp.
- Magnoliaceae: *Drimys dipetala* F.v.M.
- Anonaceae: *Eupomatia laurina* R.Br.
- Montiaceae: *Piptocalyx Moorei* Oliv.; *Wikkea macrophylla* A. DC.; *Palmeria scandens* F.v.M.; *Daphnandra micrantha* Benth.; *D. tenuipes* Perk.; *Doryphora sassafras* Endl.
- Lauraceae: *Cinnamomum Oliveri* Bailey; *C. vitens* R. T. Baker; *Litsea dealbata* Nees; *L. reticulata* Benth.; *Cryptocarya patentinervis* F.v.M.; *C. obovata* R.Br.; *C. glaucescens* R.Br.; *C. erythroxylon* Maiden & Betche; *C. Meissneri* F.v.M.; *Endlandra (vitens F.v.M.?)*; *E. Muellieri* Meissn.; *E. Sieberi* Nees; *Cassytha melantha* R.Br.
- Capparidaceae: *Capparis nobilis* F.v.M.
- Saxifragaceae: *Adrophyllum ornans* Hook.; *Cutisia viburnea* F.v.M.; *Quintinia Sieberi* A. DC.; *Q. Verdonii* F.v.M.; *Polyosma Cunninghamii* J. J. Benn.; *Anopterus Macleayanus* F.v.M.
- Pittosporaceae: *Pittosporum undulatum* Andr.; *P. revolutum* Alt.; *Hymenosporum flavum* F.v.M.; *Bursaria spinosa* Cav. var. *incana* Benth.; *Billardiera scandens* Sm.; *Citriobatus multiflorus* A. Cunn.
- Cononaceae: *Aphanopetalum resinosa* Endl.; *Geissois Benthani* F.v.M.; *Aokama Muellert* Benth.; *Schizomeria ovata* D. Don; *Ceratopetalum apetalum* D. Don; *Weinmannia rubrifolia* Benth.; *Callicoma serratifolia* Andr.
- Rosaceae: *Rubus moluccanus* L.; *R. parvifolius* L.; *R. rosaeifolius* Sm.; *R. Moorei* F.v.M.; *Acaena ovina* A. Cunn.
- Leguminosae: *Acacia juniperina* Willd.; *A. melanoxylon* R.Br.; *A. binervata* DC.; *A. floribunda* Sieb.; *A. Cunninghamii* Hook. var. *longispicata* Benth.; *A. intertexta* Sieb.; *A. mollissima* Willd.; *Cassia Sophera* L.; *Castanospermum australe* A. Cunn.; *Gastrolobium trilobatum* Benth.; *Jacksonia scoparia* R.Br.; *Daviesia corymbosa* Sm. var. *arborescens* Maiden; *Gastrolobium Boormanii* Maiden & Betche; *Hovea acutifolia* A. Cunn.; *Goodia lotifolia* Salisb.; *Indigofera australis* Willd.; *Succinosa coronillifolia* Salisb.; *Glycine clandestina* Wendl.; *Kennedya rubicunda* Vent.; *Hardenbergia monophylla* Vent.
- Geraniaceae: *Geranium dissectum* L.; *Pelargonium inodorum* Willd.
- Oxalidaceae: *Oxalis corniculata* L.
- Rutaceae: *Bosiston euodiformis* F.v.M.; *Pleiococca Wilcoxiana* F.v.M.; *Geliera salicifolia* Schott.; *Evodia micrococca* F.v.M.; *Zieria Smithii* Andr.; *Phedanthum elatius* Benth.; *Acronychia laevis* R. & G. Forst.; *A. Baueri* Schott.
- Meliaceae: *Cedrela australis* F.v.M.; *Mella Azedarach* L.; *Dysoxylum Frascranum* Benth.; *D. rufum* Benth.; *Synoum glandulosum* A. Juss.
- Tremandraceae: *Tetratheca thymifolia* Sm.
- Polygalaceae: *Camispermum ericinum* DC.
- Euphorbiaceae: *Phyllanthus gastroemii* J. Muell.; *Breytia oblongifolia* J. Muell.; *Croton Verreauxii* Baill.; *Claoxylon australe* Baill.; *Baloghia lucida* Endl.; *Homalanthus populifolius* Grah.
- Celastraceae: *Celastrus australis* Harv. & F.v.M.; *Denhamia pittosporoides* F.v.M.; *Elaeodendron australe* Vent.
- Loasaceae: *Pennantia Cunninghamii* Miers; *Charlesia Moorei* Engler.
- Sapindaceae: *Guttoa semiglaucosa* Radlk.; *Diploglottis Cunninghamii* Hook.; *Sarcopteryx stipitata* Radlk.; *Nepheklum tetocarpum* F.v.M.; *Dodonaea triquetra* Wendl.
- Akanaceae: *Akania Illii* Hook.
- Rhamnaceae: *Emmenospermum alphonsoioides* F.v.M.; *Alphitonia excelsa* Reiss.
- Vitaceae: *Vitis Baudiniana* F.v.M. (*V. anturetica* Benth.); *V. hypoglauca* F.v.M.; *V. clematidea* F.v.M.; *Cayratia Japonica* (Thunb.) Gagnepain; *C. sp. n.*
- Elaeocarpaceae: *Elaeocarpus reticulatus* Sm.; *Sloanea australis* F.v.M.; *S. Woodsii* F.v.M.; *S. Austroqueenslandica* Domin.
- Malvaceae: *Sida rhombifolia* L.; *Hibiscus heterophyllus* Vent.
- Sterculiaceae: *Brachyctenon avertifolius* F.v.M.; *B. populneus* R.Br.; *Tarretia actinophylla* Bailey; *Commersonia Fraseri* J. Gay.
- Dilleniaceae: *Hibbertia volubilis* Andr.; *H. dentata* R.Br.
- Violaceae: *Viola bettoniifolia* Sm.; *V. hederacea* Labill.
- Flacourtiaceae: *Streptothamnus Beckleri* F.v.M.
- Passifloraceae: *Passiflora alba* Link. & Otto; *P. auranti* G. Forst.

Thymelaeaceae: *Pimelia ligustrina* Labill.

Myrtaceae: *Rhodanthe trinervia* Blume; *Myrtus Beckleri* F.v.M.; *Rhodomyrtus psidioides* Benth.; *Eugenia Smithii* Poir.; *E. corymbosa* F.v.M.; *E. australis* Wendl. (*E. myrtifolia* Sims); *E. cyanocarpa* F.v.M.; *E. coolibitiana* C. Moore; *Syncarpia laurifolia* Ten.; *Backhousia myrtifolia* Hook. & Harv.; *Tristania conferta* R.Br.; *T. laurina* R.Br.; *Eucalyptus campanulata* Baker & Smith; *E. pilularis* Sm.; *E. triantha* Link. (*E. acuminatoides* Schau.); *E. altior* Maid. & Cambage (*E. oreoides* Baker); *E. microcarpa* F.v.M.; *E. paniculata* Sm.; *E. quadrangulata* Deane & Maiden; *E. saligna* Sm.; *E. grandis* Maiden; *E. propinqua* Deane & Maiden; *E. punctata* DC.; *E. Shireastii* Maid. & Blakely; *E. ornaticulata* Maiden; *E. umbellata* (Gaertn.) Domin. (*E. tereticornis* Sm.); *E. amplifolia* Naudin; *E. gummifera* Gaertn. (*E. corymbosa* Sm.); *Leptospermum flavescens* Sm.; *L. flavescens* Sm. var. *grandiflorum* Benth.; *Kunzea coriifolia* Reichb.; *Callistemon lanceolatus* DC. var.; *Melaleuca leucadendron* L.; *M. stypheloides* Sm.

Oenotheraceae: *Eptilobium glabellum* G. Forst.; *E. glabellum* G. Forst. var. *Billardieri-anum* F.v.M.

Haloragchaceae: *Haloragchis (tetragyna) (Labill.) Hook.*

Araliaceae: *Tieghemopanax Murrayi* R. Viguer; *T. sambucifolius* R. Viguer; *T. elegans* R. Viguer; *Aralia cephalobotrys* F.v.M.

Umbelliferae: *Hydrocotyle tripartita* R.Br.; *H. asiatica* L.; *H. hirta* R.Br.; *H. geraniifolia* F.v.M.

Cornaceae: *Marlea vittensis* Benth.

Epacridaceae: *Styphelia lanceolata* Sm.; *S. juniperina* Spreng. (*Leucopogon juniperinus* R.Br.); *Monotoca* sp.?; *Trochocarpa laurina* R.Br.

Myrsinaceae: *Rapanea howittiana* Mez.; *R. variabilis* Mez.; *Embellia australasica* Mez.

Sapotaceae: *Sideroxylon australe* Benth. & Hook.

Ebenaceae: *Diospyros cargilla* F.v.M.; *D. pentanera* F.v.M.

Oleaceae: *Olea paniculata* R.Br.; *Notelaea venosa* F.v.M.

Gentianaceae: *Erythraea australis* R.Br.

Apocynaceae: *Chilocarpus australis* F.v.M.; *Alyria ruscifolia* R.Br.; *Parsonsia ventricosa* F.v.M.; *Lyonsia straminea* R.Br.; *L. largiflorens* F.v.M.

Asclepiadaceae: *Tylophora paniculata* R.Br.; *Marsdenia rostrata* R.Br.

Borraginaceae: *Ehretia acuminata* R.Br.

Verbenaceae: *Clerodendron tomentosum* R.Br.; *Gmelina Leichhardtii* F.v.M.

Labiatae: *Plectranthus parviflorus* Henck.; *Mentha saturcoides* R.Br.; *Brunella vulgaris* DC.; *Prostanthera ovalifolia* R.Br. var. *latifolia* Benth.; *Ajuga australis* R.Br.

Solanaceae: *Solanum nigrum* L.; *S. opacum* A. Br.; *S. articulare* G. Forst.; *S. simile* F.v.M.; *S. verbascifolium* L. var. *auriculatum* Alt.; *S. pseudo-capsicum* L. (Introd.); *S. stelligerum* Sm.; *S. pungetium* R.Br.; *Physalis minima* L.; *Duboisia myoporoides* R.Br.

Scrophulariaceae: *Gratiola peruviana* L.; *Veronica calycina* R.Br.

Bignoniaceae: *Tecoma australis* R.Br.

Gesneriaceae: *Pieddia australis* A. Cunn.

Acanthaceae: *Eranthemum variabile* R.Br.

Myoporaceae: *Myoporum acuminatum* R.Br.

Plantaginaceae: *Plantago varia* R.Br.

Rubiaceae: *Morinda jasminoides* A. Cunn.; *Psychotria loniceroides* Sieb.

Caprifoliaceae: *Sambucus wanthocarpa* F.v.M.

Cucurbitaceae: *Melothria Cunninghamii* Benth.

Campanulaceae: *Lobelia trigonocaulis* F.v.M.; *Wahlenbergia gracilis* A. DC.

Goodeniaceae: *Goodenia Chisholmi* Blakely.

Compositae: *Olearia dentata* Moench.; *O. ramulosa* Benth.; *Siegesbeckia orientalis* L.; *Cassida longifolia* R.Br.; *Helichrysum bracteatum* Willd.; *H. clatum* A. Cunn.; *H. Beckleri* F.v.M.; *H. diosmifolium* Don; *H. ferrugineum* Less.; *Gnaphalium japonicum* Thunb.; *G. purpurcum* L.; *Erechtites prenanthoides* DC.; *Senecio amygdali-folius* F.v.M.; *S. dryadens* Sieb.

#### CORRIGENDUM.

These PROCEEDINGS, I, 1925, p. 295, and lix, 1934, pp. 143, 153.

Omit *Alsophila Cooperi* F.v.M. from text and lists.

N.B.—*A. Cooperi* is not to be found on the Comboyne, though it has been seen and collected for the National Herbarium at John's River, less than 20 miles away.

# SOME NOTES ON THE NOMENCLATURE OF CERTAIN COMMON SPECIES OF *EUCALYPTUS*.

By T. G. B. OSBORN, Department of Botany, University of Sydney.

(Plate iv.)

[Read 28th April, 1937.]

In "A Key to the Eucalypts" (1934) W. F. Blakely not only describes many new species and varieties in the large and perplexing genus *Eucalyptus*, but also makes certain changes in the nomenclature of a few well known species. Some of these changes had already been made by continental botanists during the preceding few years, but had passed more or less unnoticed. Others were made by Mr. Blakely himself.

The names which it is proposed to abandon are now in general use and have been so for 50 years or more. Under these names some of the species are widely known to foresters and timber merchants. Their change, then, is not a matter lightly to be undertaken.

The changes are:

<i>E. corymbosa</i> Sm.	to <i>E. gummifera</i> (Gaert.) Hochr.
<i>E. rostrata</i> Schlecht.	to <i>E. camaldulensis</i> Dehnh.
<i>E. tereticornis</i> Sm.	to <i>E. umbellata</i> (Gaert.) Domin.
<i>E. crebra</i> F.v.M.	to <i>E. racemosa</i> Cav.
<i>E. coriacea</i> A. Cunn.	to <i>E. pauciflora</i> Sieb.
<i>E. robusta</i> Sm.	to <i>E. multiflora</i> Poir.

In 1935 an attempt was made to conserve the names by appealing to the Nomenclature Committee of the International Botanical Congress to establish a list of *nomina specifica conservanda*. This the Committee did not see its way to recommend.

When in Europe during 1936, I took the opportunity of visiting certain herbaria and consulting with the authorities about these changes. The following notes have been compiled in the hope that they will be of service to workers on the genus, especially in Australia. Two of the proposed changes are shown to be invalid, and a third must await further evidence. In the remaining cases, the validity of the change is upheld. Photographs of the herbarium sheets of two important specimens are published. These specimens, though not actual "types", are probably as near to being so as we can hope after such a long interval of time. In one case, the change of *Eucalyptus rostrata* to *E. camaldulensis*, it is hoped that the evidence submitted will provide further argument for the conservation of certain long established specific names.

My thanks for facilities afforded me are due to the Director of the Royal Botanic Gardens, Kew; the Keeper of Botany, the British Museum of Natural History; the Linnean Society of London; the Keeper of the Botanical Department, Natural History Museum, Vienna; the Director of the Botanical Laboratory of the National Museum of Natural History, Paris. I am specially grateful to

Mr. V. S. Summerhayes for his kindness to me when working in the Herbarium at Kew.

*Eucalyptus gummifera* (Gaert.) Hochr. replacing *E. corymbosa* Sm.

The synonymy is given by B. P. G. Hochrentiner in his paper "Plantae Hochrentineranae II", *Candollea*, vol. ii, 1924-5, pp. 317-513. On p. 464 (publ. Aug., 1925) he states: "*E. gummifera*. Hochr., comb. nov. = *Metrosideros gummifera* Gaert., De Fruct. 1, 17 & 34 (1788) = *E. corymbosa*, Sm., Bot. of N. Holl. 1, 43, 1793, id. in Trans. Linn. Soc. Lond. iii, 287 (1797), . . ."

Hochrentiner notes: "Whilst it is very annoying to change a well-known name, it is impossible here not take up Gaertner's name which corresponds exactly to our species. Maiden himself says in his Monograph about Gaertner's drawing, 'unmistakable drawings of the fruit' [Maiden, Critical Revision, iv, p. 244] . . ."

In the Banksian Herbarium of the British Museum there is a single sheet of this species collected by Banks and Solander at Botany Bay in 1770. By the courtesy of the Keeper of Botany, I am able to reproduce a photograph (Pl. iv, fig. 1), which he kindly had made for me, of this specimen. It is labelled in Robert Brown's handwriting:

"*Euc. corymbosa*

*Metrosideros gummifera*

Gaert.

Botany Bay. J.B. & D.S."

Reference to the figure shows that the larger leafy shoot has only one mature fruit, the smaller has immature fruits. That there are not flowers is hardly surprising since Banks and Solander were at Botany Bay between 28th April and 8th May, which is after the usual flowering season, January-March.

The presence of but one ripe fruit may be due to the fact that a specimen or specimens of the fruit had been sent to Gaertner from the Banksian collection. These were evidently forwarded by Solander with the comment that the plant has a rough bark. Gaertner writes: "*Metrosideros gummifera*, cortice rugoso, Soland. MSS. Ex herbario Banksiano cum sequentibus." Then follows a full description, in Latin, of the fruit, seed and embryo, together with a reference to the "unmistakable drawings" referred to above.

Sir E. J. Smith had much more adequate material. In the Smith Herbarium at the Linnean Society, London, is a full sheet, with one panicle in full bloom, another with buds and opened flowers and some immature fruits. It is labelled in Smith's handwriting:

"Port Jackson, N.S.W. Mr. White 1793

*Euc. corymbosa* Bot. of N. Holland p. 43."

Further material distributed by Smith is in the British Museum (sheet numbered 124/32) and endorsed:

"N.S.W. Port Jackson. White (Dr. Smith)

*Euc. corymbosa*. Smith. New Holl. 43.v.6."

Kew also has a specimen showing leaves and flower buds, with "Presented by Sir E. J. Smith" written on the sheet.

The Banksian Herbarium is rich in specimens of this species. Some of them are of great historic interest. In addition to the crucial specimen of Banks and Solander, there are three sheets of R. Brown's collecting at Port Jackson 1802-1805, Caley's specimens, with field labels, dated 1804-1807, and one collected by A. Cunningham.

Maiden (l.c., p. 246) says he saw certain "historical specimens". Two were in the herbarium of the Botany School at Cambridge, and one at the Barbey-Boissier Herbarium, Geneva. A fourth, in which herbarium he does not state,

was of Robert Brown's collecting. This, he says, is numbered 4777. A specimen of Brown's with this number is in the Banksian Herbarium. It has the field label in Brown's handwriting: "Eucalyptus blood tree Port Jackson 1804".

If this was the specimen of No. 4777 that Maiden saw, it is curious that he did not notice the sheet in the same folder bearing Banks' and Solander's specimen. It is a reasonable assumption that it was from this specimen that Gaertner received his fruits.

In accepting Hochrentiner's new combination in place of the better known name for the common bloodwood of the Port Jackson district, one notes that the original description is based on the fruits only, except for the field note that the 'bark is rough'. It is perhaps some consolation that the name *gummifera* was apparently suggested by Solander himself.

*Eucalyptus camaldulensis* Dehnh. replacing *E. rostrata* Schlech.

This plant was described by Frederick Dehnhardt on page 20 of his "Catalogus Plantarum Camaldulensis" published at Naples in 1832 (2nd edition). The catalogue is a twenty-four page quarto pamphlet. It is apparently rather scarce, but there are copies in the libraries of the Botanical Departments of the British Museum, South Kensington, and in the Natural History Museum, Vienna.

Maiden (Critical Revision, iv, p. 66) quotes Dehnhardt's Latin diagnosis in full. He continues: "A specimen of the above in bud, communicated by Dehnhardt himself to the Vienna Herbarium, and seen by me, is *E. rostrata*." In October last, I visited Vienna to see this specimen. By kind permission of the Keeper, Hofrat Dr. K. Keissler, I had the sheet photographed (Pl. iv, fig. 2).

There are two leafy shoots, each with umbels of buds, but no expanded flowers or fruits. The operculum is conical rather than rostrate, i.e., it agrees with the conoid types figured by Maiden (l.c., Pl. 137, figs. 4a, 10, 12a) rather than the typical acutely rostrate form. In the Vienna collection are specimens communicated by Max Koch from Mt. Lyndhurst (S. Aust.) having the same type of bud. Maiden had no doubts as to the identity of the plant. His pencilled note "rostrata" appears on the sheet, as well as the printed label seen in the photograph.

There is also pasted on to the sheet a label in an old German script, possibly that of Dehnhardt himself. Maiden (l.c., p. 46) gives a not quite accurate translation of this. It is as follows: "*Eucalyptus camaldulensis* Dehnh.—Bekam ich unter dem Namen *E. persicifolia*; da ich aber späterhin den echten *E. persicifolia* bekam, bemerkte ich eine himmelweite Verschiedenheit, habe ihn auch an keinen anderen annähern können. Er ist 40 fuss hoch. [Hort. Camaldul. Dehnhardt]." The words in square brackets are added in a later hand.

A free translation of this note is: "I received this under the name of *E. persicifolia*; then later on I received the true *E. persicifolia*, I noticed an exceedingly great difference, further I could not approximate it to any other species. It is 40 feet high."

Maiden gives no reason for the suppression of Dehnhardt's name, which was validly published 15 years before Schlechtendahl's. Ewart (*Vict. Naturalist*, III, 1935, p. 64) says of *E. camaldulensis*, "The name appeared in a European Botanic Gardens list before the plant was properly described". This is hardly fair. A Latin diagnosis was published and the author communicated a specimen to one, at least, of the great herbaria of his time.

While the validity of the change is unquestionable according to the rules of Botanical nomenclature, the complete evidence provides, it seems to me, a strong argument for the establishment of a limited list of *nomina specifica conservanda*.



The plant known as *Eucalyptus rostrata* for the past 90 years is perhaps the most widespread eucalypt in all Australia. It occurs in every State except Tasmania. Under the name of *rostrata* it is cultivated in many parts of the world, for it is a valuable forest tree. Yet, because an Italian garden about 110 years ago received a batch of seed from some (today) quite unknown source under a wrong name the apt name *rostrata* becomes a synonym and an awkward, and to a large extent meaningless, name, *camaldulensis*, has to be substituted for it!

But, without special steps to conserve it, the name *rostrata* will have to go. In 1797, Cavanilles (Icones, iv, p. 23 and fig. 342) described *Eucalyptus rostratus*, which is a synonym of *E. robusta*, Sm. Under the International rules of nomenclature, Cavanilles' grammatical mistake preempted the name; *rostrata* was not available for use by Schlechtendahl in 1847.

*Eucalyptus tereticornis* Sm., Bot. New Holl., 1793, p. 41.

Domin in 1928 changed this to *E. umbellata* (Gaert.) Domin. (Bibl. I

"*Leptospermum umbellatum* (Gaertn.) Fruct., i, 174, t. 35, fig. 3, 1788." and has the following footnote: "Non Dum.-Cours., species obscura, sec. Bentham omnino neglegenda."

But, however obscure Dumont-Courset's description of *E. umbellata* may be, it is still the technical description of a eucalypt. The name *umbellata*, therefore, is already occupied and Domin was not justified in his change.

*Eucalyptus crebra* F.v.M., Journ. Linn. Soc., iii, 1859, p. 87.

Blakely takes up Cavanilles' name *E. racemosa* (Icones, iv, 1797, p. 24), but, unless an authentic specimen of this plant can be found, there is not sufficient evidence to do so. Bentham (Fl. Austr., iii, p. 200) says, "far too imperfectly described to render identification possible". Maiden (Crit. Revis., ii, p. 63) agrees. I made a search in the herbaria of Kew, the British Museum, the Linnean Society, and Natural History Museum, Paris, for any specimen of Cavanilles' *E. racemosa* that might have been communicated by him, but without success. If the herbaria in Madrid survive the present unhappy disturbances, it may be that one will be found there. At present there is no justification for dropping von Mueller's name.

*Eucalyptus pauciflora* Sieber replacing *E. coriacea* A. Cunn.

The description of Sieber's plant, No. 470, was published in Sprengel Syst. iv Cur. Post., 1827, p. 195. There are specimens of his collecting bearing this number in the Kew and British Museum Herbaria. Maiden (Crit. Revis., i, p. 135) states that he has also seen a specimen of 470 in the herbarium Barbey-Bolissier, and that it is *E. coriacea* A. Cunn.

Cunningham's plant No.  $\frac{85}{1824}$ , is in the Kew Herbarium, named in Cunningham's own hand-writing. But no description was published until 1843, when Schauer's contribution to Walper's Rep. Bot. Syst., ii, appeared.

It is hard to understand Maiden's comment (l.c., p. 133) that Sieber's name has "doubtful priority". It was properly published in 1827, whereas Cunningham's name did not appear in print until 16 years later. Maiden's comments on the suitability or otherwise of the names are irrelevant.

*Eucalyptus robusta* Sm., Bot. New Holland, 1793, p. 39.

Blakely changes the name to *E. multiflora* Polret, giving the year 1785 as that of publication. This is based on a misapprehension. Polret's description appears

in the second volume of the Supplement to l'Encyclopédie Méthodique. The date given by Blakely is that on the title page to this volume. But the volume appeared in parts over a series of years, and page 594, that on which the description of *E. multiflora* is printed, was not published till 1812 (cf. C. Davies Sherborn and B. B. Woodward, *Ann. Mag. Nat. Hist.*, Ser. vii, Vol. 17, 1906, p. 577, "On the dates of publication of the Natural History portions of the Encyclopédie Méthodique"). The change proposed by Blakely is not valid.

#### EXPLANATION OF PLATE IV.

f sheet in the Banksian Herbarium, Br  
bert Brown's handwriting reads:

"*Eucalyptus corymbosa*

*Metrosideros gummifera*

Gaert. Botany Bay. J.B. & D.S.

ripe fruit surviving on the old inflorescence in  
the right are immature.

TWO NEW SPECIES AND ONE NEW VARIETY OF *DRIMYS* FORST., WITH  
NOTES ON THE SPECIES OF *DRIMYS* AND *BUBBIA* VAN TIEGH. OF  
SOUTH-EASTERN AUSTRALIA AND LORD HOWE ISLAND.

By JOYCE W. VICKERY, M.Sc., Assistant Botanist, National Herbarium, Sydney.

(Plate v; two Text-figures.)

[Read 26th May, 1937.]

The genera *Drimys* Forst. and *Bubbia* V. Tiegh. are placed by Hutchinson (Kew Bull., 1921, pp. 185-190) in the Family Winteraceae. This family had previously been regarded as a tribe of the family Magnoliaceae, but it differs in a number of features, which mark it as being more advanced from an evolutionary point of view. This is shown particularly by the exstipulate leaves, the floral axis short and never cone-like in fruit, and the carpels arranged more or less in a single whorl. It contains about 7 genera with a more tropical and southerly distribution than the true Magnoliaceae.

*DRIMYS* FORST.

The genus *Drimys* occurs in Eastern Australia, the Malay Archipelago, New Caledonia, and South America. In New South Wales, the species are restricted either to regions of high altitude or else to the rain-forest formations characteristic of the gullies and river systems of the coastal and highland districts.

*DRIMYS PURPURASCENS*, n. sp. Plate v; ?

Frutex glaber, aromaticus, 1-2 m. altus; rami teretes purpurei juvenes; gemmae foliorum terminales in bracteis caducis purpureis angustis ovatis acuminatis 10-15 mm. longis circumdatae; folia exstipulata, alterna, in parte superiore approximata, oblanceolata, obtusa vel vix acuta, 5-16 cm. x 1-5 cm., sensim angustata ad basem sessilem 2-5 mm. latum, plana, tenuiter coriacea, subter parum pallidiora; laminae punctis pellucidis multissimis parvissimis; nervus primus purpureus in vivo, supra prominens et praesertim prope basem, vix praesertim subter; nervi secundarii angulum 45° cum nervo primo efficientes; nervi ultimi numerosiores ad marginalis; margines parum crassi; inflorescentia primo pseudo-terminali, floribus emergentibus singulis in gemmarum bractearum approximatorum axillis, tandem post rami incrementum pseudo-verticillata; alabastris ovato-globosi; flores in pedicellis 2-4 cm. longis sub-validis 1-5 mm. crassis, dioecis? vel flores staminales cum paucis carpellis; calyx disepalus; sepala concava, orbiculata, 5-7 mm. diam., alba, petala circumdata; petala 2, raro 3, ovata, obtusa, angustata ad basem, 10-12 mm. x 3-4 mm., alba; stamina numerosa, interiora primo maturescentia, receptaculo subhemisphaerico inserta; filamenta valida, parum compressa, 2-6 mm. longa, interius longiorum; anthera lata, brevia fissuris longitudinalibus dehiscentia; carpella 2-8, disiuncta, ovata, circa 2 x 1 mm. in floribus, brevissime stipitata, stigmate sessile lineare introrso et rostro parvisimo excentrico; fructus carnosus bucculis disiunctis, 2-8 plerumque 3-4, fuscis nigro-purpureis, oblongis-globosis, 10-15 mm. x 8-12 mm. maturis, stipitatis; stipes

1-3 mm. long; semines multa (circa 10) nigra, disciformia, parum rugosa, embryo prominente flexato. Mt. Royal Ranges habitat.



Text-fig. 1.—*Drimys purpurascens*, with mature fruit. A,  $\times 0.4$ . B,  $\times 1.2$ .

Barrington Tops: L. Fraser and J. Vickery, May, 1936 (Type), Nov., 1936, 7/1/1934; B. Veech, 20/11/1931; J. Hopson, Jan., 1924; L. Harrison, Jan., 1925; J. L. Boorman, Dec., 1915.

Glabrous, aromatic shrub, 1-2 m. high; branches terete, slightly glaucous, dull purplish coloured when young, smooth, or slightly rough when dry; terminal leaf-buds enclosed in caducous, purplish, narrow ovate-acuminate scales, about 10-15 mm. long; leaves exstipulate, alternate, the lower ones distant, the upper ones approximate, oblanceolate, obtuse or scarcely acute, 5-16 cm. long by 1-5 cm. wide, tapering towards the sessile, 2-5 mm. wide base, flat, thinly coriaceous, very slightly paler underneath; lamina with very numerous, very small, pellucid dots; midrib purple-coloured when fresh, prominent and protruding on the upper surface, especially near the base, scarcely protruding on the lower surface, the secondary veins making an angle of  $45^\circ$  with the midrib, the finer veins more numerous towards the margins; margins very slightly thickened; inflorescence at first pseudo-terminal, the flowers arising singly in the axils of the closely-spaced bud-scales,

then by further growth of the shoot the inflorescence becomes pseudo-verticillate; flower buds ovate globose; flowers dioecious? or the staminate flowers bearing few carpels, on moderately stout pedicels 2-4 cm. long  $\times$  1.5 mm. thick; female flowers not seen; calyx of 2 concave sepals enclosing the petals, the sepals orbicular, about 5-7 mm. diameter, white; petals 2, rarely 3, ovate, obtuse, slightly narrowed at the base, 10-12 mm.  $\times$  3-4 mm., white; stamens numerous, inserted on the sub-hemispherical receptacle, the inner ones ripening first; filaments stout, slightly compressed, 2-6 mm. long, those of the inner stamens the longest; anthers broad, short, opening by lateral, longitudinal slits; carpels 2-8, free, about 2 mm.  $\times$  1 mm., ovate, very shortly stipitate, with a sessile, linear, introrse stigma, and a very small excentric beak; fruit succulent, of 2-8, usually 3-4, free berries, deep blackish-purple in colour, oblong globose, about 10-15 mm.  $\times$  8-12 mm. at maturity, each carpel shortly stipitate, the stipe 1-3 mm. long.

So far this species has been found only in a restricted area on the Mt. Royal Ranges in the vicinity of the Barrington Tops, where it occurs abundantly at an altitude of about 4,500 feet, in a *Eucalyptus coriacea*-*Poa caespitosa* association. It can be readily distinguished by its large oblanceolate leaves with purplish midrib, and its large dark purple fruit consisting usually of several carpels, which hang in handsome clusters.

*DRIMYS STIPITATA*, n. sp. Text-fig. 2.

Frutex vel raro parum arborescens, glaber, 1-2.5 m. altus; rami teretes, aliquantuli glauci, hebetes-purpurelli iuvenes; gemmae foliorum terminales in bracteis caducis purpurellis ovatis acutis circa 5-12 mm. longis circumdatae; folia exstipulata, alterna, in parte superiore approximata, sessila vel subsessila, lanceolata, acuta, 5-13 cm.  $\times$  0.7-2 cm., plana, parum pallida subter in sicco, reticulata; laminae punctis pellucidis multissimis parvissimis, saepe non cernandis per textum foliorum; nervus primus parum prominens utrinque prope basem; nervi secundarii obliquissimi, angulum acutum cum nervo primo efficientes; inflorescentia primo pseudo-terminalis, floribus emergentibus singulis in axillis bractearum gemmarum approximatarum, tandem post incrementum rami pseudo-verticillata; flores in pedicellis aliquantis gracilibus circa 1.5-2 cm. longis vel ad 2-4 cm. posthac producentibus, dioeciae? vel flores staminales cum paucis carpellis; calyx disepalus; sepala concava, late ovata, sub-acuta, circa 6 mm.  $\times$  4 mm., alba, petala circumdata; petala 2, ovata, angustata ad basem, obtusa, circa 5-6 mm.  $\times$  1.5 mm., alba; stamina numerosa, interiora primo maturescentia; filamenta aliquanta valida compressa, 1-5 mm. longa, interiora longissima; anthera lata, brevibus fissuris longitudinalibus dehiscentia; carpella 2-8, disjuncta, longe stipitata, stigmata sessile lineare introrso; fructus carnosus, 2-8 bacculis apocarpis stipitatis; stipes gracilis, 4-8 mm. longus; fructus maturus non viasus; fructus iuvenior circa 6 mm.  $\times$  4 mm., 12-15 seminibus 2 mm. diam. disciformibus embryone prominente flexato. Declivitates orientes N.S.W. septentrionalis habitat. (Synonym: *D. aromatica* var. *pedunculata* Maiden, *Agric. Gaz. N.S.W.*, v, 1894, 600.)

Guy Fawkes, J. H. Maiden, Feb., 1895 (Type); Jeogla, L. Fraser and J. Vickery, 24/1/34; Dorrigo State Forest, C. T. White, 7572, 4/10/1930; Upper Hastings River, J. H. Maiden, Nov., 1897; Walcha, J. F. Campbell, Nov., 1899; Backwater (without flower or fruit), Rev. E. N. McKie, 29/9/1932; Clarence River, Wilcox, No. 1875; Hastings River, Dr. Beckler.

Tall, glabrous shrub, or rarely somewhat arborescent, 1-2.5 m. high; branches terete, slightly glaucous and dull purplish when young; terminal leaf-buds enclosed in caducous, ovate, acute, purplish scales, about 5-12 mm. long; leaves exstipulate,

alternate, the upper ones rather approximate, sessile or subsessile, lanceolate, acute, 5-13 cm. long by 0.7-2 cm. broad, flat, slightly paler underneath when dry, net-veined, the midrib slightly protruding on each side near the base, the secondary veins very oblique, making an acute angle with the midrib; pellucid dots very



Text-fig. 2.—*Drimys stipitata*, with immature fruit

small, numerous, often invisible owing to the texture of the leaf; inflorescence at first pseudo-terminal, the flowers arising singly in the axils of the closely-spaced bud-scales, then by further growth of the shoot the inflorescence becomes pseudo-verticillate; flowers on rather slender pedicels about 1.5-2 cm. long which elongate to 2-4 cm. after flowering, dioecious? or the staminate flowers bearing few carpels; calyx of 2 concave, broadly ovate, subacute, white sepals about 6 mm.  $\times$  4 mm., enclosing the petals; petals 2, ovate, narrowed at the base, obtuse, 5-6 mm.  $\times$  1.5 mm., white; stamens numerous, the inner ones ripening first; filaments fairly stout, compressed, 1-5 mm. long, those of the inner stamens the longest; anthers broad, short, opening by longitudinal slits; carpels 2-8, free, stipitate, with a sessile linear introrse stigma; fruit succulent, consisting of 2-8 free, oblong, stipitate berries, the stipe slender, 4-8 mm. long; mature fruits not seen; younger fruiting carpels about 6 mm.  $\times$  4 mm., each with about 12-15 flat, discoid seeds, about 2 mm. diam., with strongly curved embryos.

In his description of *D. aromatica* var. *pedunculata* Maiden states: "The umbels are not only not sessile, but the peduncles are half to  $1\frac{1}{2}$  inch long in my specimens, while the pedicels are short (half an inch). In both *D. aromatica* and *D. dipetala* the umbels are sessile and the pedicels are much longer than in my specimens." From an examination of the specimens described by Maiden, it is evident that the above description is due to a misconception, the "peduncles" being the pedicels of the flowers comparable with those of the other species mentioned, and the "pedicels" the stipes of the numerous carpels. I have, therefore, considered it

inadvisable to make use of the varietal name *pedunculata* when raising this form to specific rank.

This species is found at an altitude of about 2,000–4,000 feet, on the eastern slopes of the coastal range of northern New South Wales. It is characterized particularly by the long stipes of the carpels, especially when in fruit.

DRIMYS INSIPIDA Druce, Bot. Soc. and Exch. Club, 1917.

Synonyms: *Tasmannia insipida* R.Br., in De Candolle's *Regni Vegetabilis Systema*, 1, 1818, p. 445–6.—*Tasmannia dipetala* R.Br., in De Candolle's *Prod.*, 1, 1824, p. 78.—*Drimys dipetala* F.v.M., *Plants Indigenous to the Colony of Victoria*, 1, 1860–1864, p. 21; Bentham, *Fl. Aust.*, 1, 1863, p. 49; Maiden & Betche, *Census of N.S.W. Plants*, 1916, p. 79.—*Drimys insipida* Domin, *Biblioth. Bot.*, lxxix, 1925, p. 115.—*Tasmannia monticola* A. Rich., *Sert. Astrolab.*, 1834, p. 50.

In his description of *T. monticola*, Richard states that it differs from *T. insipida* in the more elongated leaves, more contracted at their base, and in the hermaphrodite flowers, disposed in a simple umbel at the ends of the branches. The staminate flowers of *D. insipida*, however, often show the presence of a carpel, and, when first formed, the flowers arising in the axils of the bud scales do appear to form a terminal umbel, but this appearance is altered when the terminal shoot continues its growth. A specimen in the National Herbarium collected by Fraser before 1833 is probably a cotype of *T. monticola*, and does not differ from *D. insipida*.

DRIMYS LANCEOLATA Baill., *Nat. Hist. Pl.*, 1, 1871, p. 154.

Synonyms: *Winterania lanceolata* Poir., *Encycl.*, viii, 1808, p. 799–800.—*Tasmannia aromatica* R.Br. in De Candolle's *Regni Vegetabilis Systema*, 1, 1818, p. 455, and De Candolle's *Prodromus*, 1, 1824, p. 78.—*Drimys aromatica* F.v.M., *Plants Indigenous to the Colony of Victoria*, 1860–1862, p. 20–21; Bentham, *Fl. Aust.*, 1, 1863, p. 49; Maiden & Betche, *Census of N.S.W. Plants*, 1916, p. 79.

*Winterania lanceolata* Poir. and *Tasmannia aromatica* R.Br. have been regarded as synonyms by De Candolle (1824) and by Baillon (1871), and it is probable that these authors were able to compare the types. *W. lanceolata* was described from fruiting but not flowering material, and in certain respects the description is difficult to reconcile with *T. aromatica* R.Br., viz., . . . leaves opposite . . . petioles scarcely 6 lines long . . . flowers lateral and terminal, situated in the axils of the leaves and disposed in small simple clusters, almost umbels, scarcely longer than the petioles . . . fruit of small, globular, three-lobed berries, with the persistent calyx at their base. In other respects, however, the description appears to agree with *T. aromatica*.

In addition, the locality of collection of *Winterania lanceolata*, namely, the coast of New Holland, makes it more than probable that the species concerned is identical with *T. aromatica*.

*D. lanceolata* is found in Tasmania, where it apparently grows almost at sea-level, but in Victoria, and more especially in New South Wales, it is restricted to higher altitudes. It is a common constituent of the flora of the Australian Alps, extends along the eastern highlands of New South Wales at altitudes of 2,000–4,000 feet, as at Clyde Mt. and on the Blue Mountains, and occurs at an altitude of about 4,500 feet on the Barrington Tops. The specimens from the Australian Alps and Tasmania often have distinctly thicker, more coriaceous leaves than those from the Clyde Mt., Blue Mts., and Barrington Tops, but, as the specimens agree closely in other respects, it is probable that the variation is due merely to habitat factors.

*DRIMYS LANCEOLATA* Druce var. *PARVIFOLIA*, n. var.

Ab typo parvo habito, ramis conrescentibus, foliis approximatis parvis, coriaceis, lanceolatis, vel spathulatis, plerumque obtusis, 8-23 mm. x 2-5 mm., et floribus parvioribus, petalis circa 2 mm. longis differt.

Localities: Upper Yarra, Victoria, J. Staer, April, 1911 (Type); Gippsland, C. French, 1895; Mt. Mueller near Mt. Baw Baw, Melvin, 1889; Mt. Wellington, Gippsland, Dr. Mueller, Nov., 1854; Summit of the Baw Baw Ranges 4-5,000 feet, Dr. Mueller.

This variety differs from the type in its small habit, condensed branches, approximate, small, coriaceous, lanceolate or spathulate, usually obtuse leaves 8-23 mm. long by 2-5 mm. wide, and small flowers with petals about 2 mm. long. It appears very distinct from typical *D. lanceolata*, but as this species varies considerably in leaf size and texture according to the degree of exposure and low temperature to which it is subjected, field observations would be necessary before it could be decided whether this variety is worthy of specific rank.

*Imperfectly known species.*

The following species were named apparently from material sent from Victoria by von Mueller. In each case the descriptions are very brief, except in regard to the anatomy. I have examined the Australian material of *Drimys* from the Melbourne National Herbarium, and can find no specimens which could be regarded as cotypes of these species.

*Drimys xerophila* Parmentier, *Bull. Sc. France et Belg.*, xxvii, 1895, p. 225-226 and 299-300. This species is probably synonymous with *D. lanceolata*.

*Drimys Muellieri* Parmentier, *Bull. Sc. France et Belg.*, xxvii, 1895, p. 227, 300. As Van Tieghem (*Journ. de Bot.*, xiv, 1900, p. 283-4) has pointed out, it is doubtful whether this species belongs to the genus *Drimys*, since it was described as showing vessels in the secondary wood.

*Drimys intermedia* Parmentier, *Bull. Sc. France et Belg.*, xxvii, 1895, p. 223, 224. This species is probably synonymous with *D. lanceolata*.

*Key to the species of Drimys in New South Wales.*

Leaves 1-8 cm. long; petals usually more than 2; fruit globose consisting of 1 sessile carpel, bilobed, about 5 mm. diameter.

Leaves 2.5-8 cm. mostly about 5 cm. long, usually more or less acute, lanceolate. .... *Drimys lanceolata*.

Leaves 1-2.5 cm. long, lanceolate or spathulate, usually obtuse. .... *Drimys lanceolata* var. *parvifolia*.

Leaves 8-20 cm. long, rarely less; petals usually 2; berries more or less oblong.

Fruit consisting of 1 sessile carpel, about 12-16 mm. long; blade distinctly truncate and slightly auriculate at the base; petioles 2-4 mm. long; small tree with lanceolate, acute or acuminate leaves, inhabiting brush forests. .... *Drimys insipida*.

Fruit consisting of several carpels; blade not or scarcely truncate at the base, sessile or subsessile.

Carpels shortly stipitate; leaves oblanceolate, broad, obtuse, the secondary veins forming an angle of about 45° with the midrib. . . *Drimys purpurascens*.

Carpels on long stipes; leaves rather narrow lanceolate, acute, the secondary veins oblique, forming an acute angle with the midrib. .... *Drimys stipitata*.

*BUBBIA* Van Tieghem.

The genus *Bubbia* is distinguished from *Drimys* in having a small calyx which exposes the petals in bud, while in *Drimys* the calyx encloses the petals in bud.



It is further distinguished from the Australian species of *Drimys* by its inflorescence, which is in the form of a terminal cluster of many-flowered cymes. (Hutchinson, *Kew Bull.*, 1921, p. 189; Van Tieghem, *Journ. de Bot.*, xiv, 1900, p. 293.) It is a small genus occurring in Lord Howe Island, New Caledonia, and New Guinea.

*BUBBIA HOWEANA* V. Tiegh., *Journ. de Bot.*, xiv, 1900, p. 293.

Synonyms: *Drimys Howeana* F.v.M., *Fragm. Phytog. Austral.*, vii, 1869-1871, p. 17.—*Drimys insularis* Baill. of F.v.M., *Fragm. Phytog. Austral.*, ix, 1875, p. 76.

Van Tieghem (1900, p. 292) recognizes a second species of *Bubbia* from Lord Howe Island, viz., *B. Mülleri* V. Tiegh. This species was named apparently without flowers or fruit, and no description is given by Van Tieghem. It is not represented in the Sydney National Herbarium.

In conclusion, I desire to thank Mr. R. H. Anderson, Botanist and Curator of the National Herbarium, Sydney, for his interest and assistance during the progress of the work. I wish also to acknowledge the courtesy of Mr. F. J. Rae, Director of the Botanic Gardens, Melbourne, in allowing me to examine the Australian specimens of *Drimys* contained in the Melbourne National Herbarium.

#### EXPLANATION OF PLATE V.

*Drimys purpurascens*, on the Barrington Tops Plateau.

REVISION OF AUSTRALIAN LEPIDOPTERA. OECOPHORIDAE.

By A. JEFFERIS TURNER, M.D., F.R.E.S.

[Read 26th May, 1

56. Gen. *ISCHNOMORPHA*, n.g. (*ισχνομορφος*, narrow.)

I substitute this name for *Ischnophanes*, which is preoccupied.

63. Gen. *ECDREPTA*, n.g. (*εκδρεπτος*, picked out.)

I substitute this name for *Eccrita*, which is preoccupied.

65. Gen. *MERMERISTIS* Meyr.

*Erot. Micro.*, i, p. 298.

Tongue present. Palpi with second joint not reaching base of somewhat thickened with appressed scales, terminal joint nearly as long slender, acute. Antennae with basal pecten, ciliations in male long, with 2 and 3 separate, 7 and 8 coincident. Hindwings elongate-ovate; normal.

527. *†spodiaca* Meyr., *Erot. Micro.*, i, p. 298 (Tasmania).

66. Gen. *ANTIDIC*

*PROC. LINN. SOC. N.S.W.*, 1883, p. 382. *Latom.*

*Coleoptera*, 1842).

Tongue present. Palpi much exceeding base of antennae,  $2\frac{1}{2}$  times length of face, moderately thickened with scales, which are slightly rough anteriorly, terminal joint about two-thirds, slender. Antennae with basal pecten; in male moderately ciliated. Abdomen stout; terminal segments broadened by small lateral scale-tufts. Forewings narrow; 7 to apex. Hindwings as broad as forewings; neuration normal.

I have satisfied myself that 7 of forewings runs usually to apex, though sometimes slightly beneath. The peculiar abdomen sufficiently distinguishes the genus from *Eulechria*.

Three species: 528. *pilipes* Butl., *Ann. Mag. Nat. Hist.* (5), ix, p. 102 (Warwick, Q., to Melbourne) = *eriomorpha* Meyr., *P.L.S.N.S.W.*, 1883, p. 382.—529. *pseudomorpha*, n. sp. (Castlemaine).—530. *barysoma* Meyr., *P.L.S.N.S.W.*, 1883, p. 382 (Deloraine, Tas.).

529. *ANTIDICA PSEUDOMORPHA*, n. sp. (*ψευδομορφος*, of deceptive appearance.)

♂. 23–26 mm. Head and thorax ochreous-grey-whitish. Palpi fuscous. Antennae grey; in male evenly ciliated, ciliations scarcely 1. Abdomen grey. Legs fuscous. Forewings narrow, costa slightly arched, apex pointed, termen very oblique; brown-whitish; a fuscous subcostal streak from base to apex, becoming broader towards apex; cilia pale grey. Hindwings and cilia grey.

Very similar to *A. pilipes*, which is smaller, has whiter forewings, and whose antennal ciliations are  $1\frac{1}{2}$  and arranged in tufts.

Victoria: Castlemaine in February and March (Dr. W. E. Drake); three specimens.

67. Gen. *EULECHRIA* MEYR.

PROC. LINN. SOC. N.S.W., 1882, p. 508.

Tongue present. Palpi recurved, ascending; second joint thickened with smoothly appressed scales, sometimes slightly rough anteriorly, or with some loose scales towards apex, sometimes not reaching, but usually reaching, base of antennae, sometimes much exceeding this and 2 or 3 times length of face; terminal joint usually shorter, but sometimes as long as second ( $\frac{1}{2}$  to 1), slender, acute. Antennae with basal pecten; ciliations of male short, moderate, or long. Thorax not crested. Forewings with 7 to apex, or occasionally (in the same species) just beneath apex. Hindwings elongate-oval; 3 and 4 usually connate, rarely separate or stalked, 5 usually from middle of cell, but sometimes slightly curved and approximated to 4 at origin.

Type, *E. cranimis* Meyr. The species are abundant throughout Australia and Tasmania, with a few stragglers elsewhere, one in New Zealand, a few in the Archipelago and India, and one in South Africa. This very large genus shows considerable diversity of structure, especially in the length of the second and third joints of the palpi. Unfortunately it has not proved possible to make use of these for generic subdivision. The species are mostly of cryptic coloration and many are extremely similar, so that their discrimination needs careful study, including such structural points as the relative lengths of the joints of the palpi and of the antennal ciliations.

Within the genus are contained two large and several smaller groups of species. The largest group is characterized by the presence of five or more discal dots arranged in an irregular oval (*foedatella*, *siccella*, etc.); the next (*convictella*, etc.) by three discal dots only. It is not certain that these two groups are really monophyletic; where their markings are distinct there is no difficulty in separating them; but in both groups there are unicolorous species, not so easily placed. If we endeavour to divide the genus on characters derived from the palpi, we cut across both groups. The resulting assemblages are certainly artificial, and not even helpful in the determination of species.

*Eulechria* gives origin to various other smaller genera, of which *Macronemata*, distinguished only by its lanceolate hindwings, is the largest. *Eulechria* and *Philobota* are very closely allied, the only distinguishing point being the termination of vein 7 of the forewing in the apex or termen. In most instances this is easy to determine. In some species with rounded apices to the forewings the exact position of the "anatomical apex" (These PROCEEDINGS, 1935, p. 1) is hard to fix. When, as occasionally happens, vein 7 in the same species varies between this apex and a point very shortly beneath, that species should, in my opinion, be referred to *Eulechria* and not to *Philobota*.

Three hundred and sixty-two species.

531. *EULECHRIA XANTHORSTEPHANA* Meyr., P.L.S.N.S.W., 1887, 952 (Toowoomba to Melbourne, Mt. Kosciusko, Mt. Lofy).
532. *EULECHRIA METABAPTA* Meyr., *Exot. Micro.*, 1, 164 (Cairns, Atherton, Innisfail).
533. *EULECHRIA MONOZONA* Meyr., P.L.S.N.S.W., 1888, 1582 (Perth, Waroona, York, W.A.).
534. *EULECHRIA HELIODORA* Meyr., *Ibid.*, 1887, 948 (Geraldton, W.A.).
535. *EULECHRIA HYMENAEA* Meyr., *Tr.R.S.S.Aust.*, 1902, 149 (Duaranga, Warwick, Charleville).
536. *EULECHRIA XANTHOPHYLLA*, n. sp. (*ξανθοφύλλος*, yellow-winged.)

♂. 14 mm. Head yellow. Palpi with second joint just reaching base of antennae, terminal joint three-fourths; yellow. Antennae fuscous; ciliations in

male 1. Thorax fuscous. Abdomen fuscous; beneath pale yellow. Legs fuscous; posterior pair yellow. Forewings elongate, costa gently arched, apex rounded, termen obliquely rounded; yellow; costal edge fuscous in basal fourth; a moderate fuscous terminal band, paler posteriorly; cilia whitish, on tornus fuscous. Hindwings and cilia grey.

Smaller than *E. malacoptera*, the antennal ciliations shorter (in *malacoptera* 2), palpi wholly yellow, and thorax wholly fuscous.

Queensland: Coolangatta in April; one specimen.

537. *EULECHRIA MALACOPTERA* MEYR., P.L.S.N.S.W., 1887, 948 (Stradbroke Is., and Stanthorpe to Melbourne, Pt. Lincoln).

538. *EULECHRIA XUTHOPHYLLA*, n. sp. (ξουθοφυλλος, tawny-winged.)

♀. 16 mm. Head pale yellow. Palpi with second joint reaching base of antennae, terminal joint three-fourths; pale yellow, terminal joint and base of external surface of second joint fuscous. Antennae fuscous. Thorax fuscous. Abdomen fuscous; apices of terminal segments whitish; underside yellowish. Legs fuscous; posterior pair pale yellow. Forewings elongate, costa gently arched, apex rounded, termen obliquely rounded; ochreous-yellow tinged with brown; a dark fuscous discal dot at two-thirds, connected by a fuscous suffusion with tornus; cilia yellowish, on tornus fuscous. Hindwings grey; cilia grey, on apex whitish-yellow.

New South Wales: Mittagong in January; one specimen.

539. *EULECHRIA MONOSPILA*, n. sp. (μονοσπιλος, one-spotted.)

♂, ♀. 21-23 mm. Head and thorax ochreous-yellow. Palpi with second joint reaching base of antennae, terminal joint three-fifths; ochreous-yellow, outer surface of second joint except apex and apex of terminal joint fuscous. Antennae fuscous; ciliations in male 1. Abdomen brownish-fuscous; apices of segments pale grey; tuft ochreous. Forewings suboval, costa gently arched, apex rounded, termen obliquely rounded; ochreous-yellow; costal edge dark fuscous towards base; a short inwardly oblique dark fuscous mark from costa at four-fifths; cilia ochreous yellow. Hindwings grey; cilia ochreous-grey.

Queensland: Toowoomba in November; four specimens received from Mr. W. B. Barnard, who has the type.

540. *EULECHRIA EURYNECA*, n. sp. (εὐρυνεκος, broadly pale yellow.)

♂. 20-23 mm. Head ochreous. Palpi with second joint exceeding base of antennae, terminal joint three-fifths; dark fuscous, terminal joint whitish except in front. Antennae fuscous; ciliations in male 3. Thorax dark fuscous. Abdomen fuscous; tuft ochreous. Legs fuscous. Forewings rather narrow, slightly dilated, costa straight except towards base and apex, apex rounded, termen obliquely rounded; pale yellow; a narrow blackish basal fascia prolonged sometimes along costa to one-fifth; a broad grey terminal band; an apical grey blotch; cilia grey on apical half of termen, pale yellow on tornal half, on tornus with bases blackish. Hindwings pale yellow; a small fuscous basal patch; a grey band around apex; cilia pale yellow.

Victoria: Daytrap near Sea Lake in September; two specimens received from Mr. Geo. Lyell, who has the type.

541. *EULECHRIA PHAENA* TURN., *Tr.R.S.S.Aust.*, 1896, 14 (Brisbane, Toowoomba).

542. *EULECHRIA AXIERASTA* TURN., P.L.S.N.S.W., 1916, 357 (Tweed Heads, Toowoomba, Bunya Mts., Stanthorpe).

543. *EULECHRIA CURVILINEA* TURN., *Tr.R.S.S.Aust.*, 1896, 12 (Atherton, Rockhampton to Tweed Heads).

544. *EULECHRIA DIPLOLETHRA* Turn., P.L.S.N.S.W., 1916, 358 (Mt. Tambourine, Macpherson Range).

545. †*EULECHRIA EPIPIRAGMA* Meyr., *ibid.*, 1887, 954 (Quorn, S.A.).

546. *EULECHRIA PLATYRHABDA*, n. sp. (πλατυρῥαβδος, broadly barred.)

♀. 16 mm. Head white. Palpi with second joint reaching base of antennae, expanded towards apex, terminal joint three-fourths; white, base of second joint fuscous. Antennae fuscous. Thorax white; lateral and posterior margins broadly fuscous. Abdomen grey; tuft pale ochreous. Legs fuscous with whitish rings; posterior pair whitish-ochreous. Forewings narrow, costa gently arched, apex pointed, termen oblique; white with dark fuscous markings; a narrow basal fascia; a broad transverse fascia before middle, expanded on costa and more strongly so on dorsum; a third fascia from costa before apex inwards, bent in disc at a right angle, ending on tornus moderately broad, its angle connected by a narrow stria with costa; an elongate spot on termen; cilia fuscous, on apex white, apices ochreous-whitish, on tornus wholly fuscous. Hindwings elongate-ovate; 5 from middle; grey; cilia grey.

Not unlike *E. schalidota*, but that species has no basal fascia in the forewings and the thorax is white posteriorly.

Queensland: Westwood in October; one specimen received from Mr. G. M. Goldfinch, who has the type.

547. *EULECHRIA SCHALIDOTA* Meyr., P.L.S.N.S.W., 1887, 955 (= *dichroa* Low., *Tr.R.S.S.Aust.*, 1894, 95) (Townsville, Rockhampton, Duaringa).

548. *EULECHRIA EPICAUSTA* Meyr., P.L.S.N.S.W., 1882, 525 (Tweed Heads, Toowoomba, Stanthorpe, Milmeran).

549. *EULECHRIA TRIFERELLA* Wlk., xxix, 684; Meyr., P.L.S.N.S.W., 1882, 523 (Yeppoon to Melbourne).

550. *EULECHRIA TROPICA* Meyr., P.L.S.N.S.W., 1887, 955 (Darwin, Thursday Is., to Brisbane, New Guinea).

551. *EULECHRIA NEPHOBOLA*, n. sp. (νεφροβολος, clouded.)

♂, ♀. 18–20 mm. Head white. Palpi with second joint reaching base of antennae, terminal joint three-fifths; fuscous, apex of second joint and terminal joint except apex whitish. Antennae fuscous; ciliations in male two-thirds. Thorax fuscous, with an anterior, sometimes also a posterior, spot. Abdomen fuscous; tuft ochreous-whitish. Legs fuscous; posterior pair ochreous-whitish. Forewings moderate, costa rather strongly arched, apex round-pointed, termen obliquely rounded; white with more or less patchy fuscous irroration; markings fuscous; a straight narrow fascia from one-third costa to two-fifths dorsum, variably developed, sometimes not reaching costa, sometimes dilated on dorsum, and sometimes also on costa, a dot beneath costa at two-fifths, and another above dorsum at three-fifths, but these may either be distinct, minute or obsolete; a second fascia from two-thirds costa to tornus; a large costal spot near apex, giving rise to a fine, sometimes interrupted, line to tornus; cilia whitish with an obscure antemedian fuscous line. Hindwings with 5 from middle of cell; pale grey; cilia pale grey.

Queensland: Southport in December. New South Wales: Tweed Heads and Brunswick Heads in December and January. Six specimens.

552. *EULECHRIA OMBRODES* Low., *Tr.R.S.S.Aust.*, 1897, 56 (Rockhampton, Miles).

553. *EULECHRIA CHRYSOMOCHIA*, n. sp. (χρυσομοχλος, golden-barred.)

♂, ♀. 15–18 mm. Head white. Palpi with second joint reaching base of antennae, terminal joint four-fifths; white, basal half of second joint and anterior

edge of terminal joint brown. Antennae fuscous; ciliations in male two-thirds. Thorax golden-brown. Abdomen brown. Legs brown; posterior pair whitish-ochreous. Forewings moderate, not dilated, costa gently arched, apex rounded, termen rounded, slightly oblique; white with golden-brown markings; a basal costal spot; a moderate fascia from one-fourth costa to one-third dorsum, dilated on dorsum; a similar fascia from three-fourths costa to tornus, dilated on costa; a narrower terminal fascia; cilia golden-brown, apices whitish. Hindwings with 5 from middle of cell; pale grey; cilia pale grey.

Allied to *E. ombrodes* and *E. eurygramma*. Distinguished from the latter by the golden-brown colour of markings and by the postmedian and terminal fasciae not being confluent.

Queensland: Chinchilla in October; Miles in November; Roma in September; five specimens.

554. *EULECHRIA EURYGRAMMA* Turn., P.L.S.N.S.W., 1916, 359 (Atherton).

555. *EULECHRIA PEISTERIA*, n. sp. (πεισθηριος, persuasive.)

♂. 20 mm. Head white. Palpi with second joint reaching base of antennae (terminal joint missing); white, base of second joint fuscous. Antennae grey; ciliations in male two-thirds. Thorax white; anterior edge and a posterior spot fuscous. Abdomen ochreous-whitish. Legs ochreous-whitish; anterior pair fuscous. Forewings moderate, not dilated, costa moderately arched, apex round-pointed, termen obliquely rounded; white; markings brown, clearly defined; a curved sub-basal fascia; a narrow fascia from one-fifth costa to one-third dorsum, strongly dilated on dorsum; a discal dot beneath one-third costa, and a second in middle above fold; a third rather broader fascia from beyond three-fifths costa to tornus, interrupted beneath costa; an inwardly oblique streak from costa before apex, angled in disc and continued as a curved line to tornus; cilia white, on tornus brown. Hindwings with 5 from middle of cell; whitish-ochreous-grey; cilia concolorous.

Queensland: Adavale in May; one specimen.

556. *EULECHRIA COSMOSTICHA*, n. sp. (κοσμοστιχος, prettily lined.)

♂. 19 mm. Head white. Palpi with second joint reaching base of antennae, terminal joint three-fourths; white. Antennae grey; ciliations in male 2½. Thorax white; anterior edge fuscous. Abdomen pale ochreous-grey. Legs white; tarsi fuscous; anterior pair fuscous. Forewings rather narrow, costa slightly arched, apex rounded, termen obliquely rounded; white, markings brownish-fuscous; a small basal fascia with rounded edge, more developed towards costa; a narrow fascia from one-third costa to one-third dorsum, slightly outwardly curved, dilated on costa; a discal spot at two-thirds; a rounded apical blotch, partly whitish-grey, almost touching discal spot, giving off a terminal line, from which proceeds a small process towards, but not reaching, discal spot; cilia ochreous-grey. Hindwings with 5 from well below middle of cell (one-third); grey; cilia ochreous-grey.

Queensland: Toowoomba in February; one specimen received from Mr. W. B. Barnard.

557. *EULECHRIA CALOTROPHIA* Meyr., P.L.S.N.S.W., 1882, 536 (Brisbane and Toowoomba to Sydney).

558. †*EULECHRIA ACERAE* Meyr., *ibid.*, 1883, 324 (Birchip, Petersburg, S.A.).

559. *EULECHRIA LEUCOPHANES* Meyr., *ibid.*, 1883, 320 (Pt. Lincoln).

560. *EULECHRIA IRENAEA* Meyr., *ibid.*, 1887, 962 (Petersburg).

561. †*EULECHRIA CHOLERODES* Meyr., *ibid.*, 1886, 963 (Carnarvon, W.A.).

562. *EULECHRIA EPIBORCA*, n. sp. (*ἐπιβορκος*, upon the grass.)

♂, ♀. 16-22 mm. Head and thorax white. Palpi with second joint reaching base of antennae, terminal joint three-fourths; whitish, external surface of second joint except apex, and apex of terminal joint fuscous. Antennae grey, towards base whitish; ciliations in male slightly more than 1. Abdomen dark grey; apices of segments and tuft paler. Legs fuscous; posterior pair grey. Forewings elongate, narrow, costa gently arched, apex rounded, termen very oblique; white; base of costal edge fuscous; cilia white. Hindwings with termen gently rounded; 5 from middle of cell; dark grey, in female whitish-grey; cilia whitish.

Narrower winged than *E. candida*, the hindwings of male darker grey, and the antennal ciliations rather longer (in *candida* two-thirds), and, unlike that species, the female is smaller, with paler hindwings.

Queensland: Toowoomba in September, October, and April; Bunya Mts. (3,500 feet) in February and March; fifteen specimens.

563. *EULECHRIA CANDIDA* Turn., *Tr.R.S.S.Aust.*, 1898, 206 (Brisbane, Toowoomba and Bunya Mts., to Armidale).

564. *EULECHRIA OMOPASTA*, n. sp. (*ὀμωπαστος*, with peppered shoulders.)

♂. 22-26 mm. ♀. 28-30 mm. Head whitish, more or less ochreous-tinged. Palpi with second joint reaching base of antennae, terminal joint three-fifths to three-fourths; ochreous-whitish. Antennae whitish; ciliations in male 3. Thorax ochreous-whitish; usually some fuscous or blackish scales at base of tegulae. Abdomen ochreous-grey-whitish, bases of segments darker. Legs fuscous; posterior pair ochreous-grey-whitish. Forewings moderately broad, not dilated, costa gently arched, apex round-pointed, termen obliquely rounded; ochreous-whitish; costal edge towards base blackish; cilia ochreous-whitish. Hindwings with 5 from middle; pale grey; cilia whitish.

Extremely like *E. pallidella*, but the head is more ochreous, antennal ciliations much longer and females rather larger than males.

Queensland: Toowoomba in April; Stanthorpe in May; National Park (2,000 feet in open forest) in February; eleven specimens. An autumnal species.

565. *EULECHRIA PALLIDELLA* Meyr., *P.L.S.N.S.W.*, 1882, 519.

♂. 19-23 mm. ♀. 17-22 mm. Antennal ciliations in male 2. Discal dots never present in forewings. Females narrower-winged and on the whole smaller than males. A species of the spring and earlier summer months. (Yeppoon to Tweed Heads, Toowoomba, Warwick, Stanthorpe.)

566. †*EULECHRIA MONODA* Low., *Tr.R.S.S.Aust.*, 1907, 115 (N.Q.).

567. *EULECHRIA SALSICOLA* Meyr., *Erot. Micro.*, 4, 162 (Gisborne, Birchip).

568. *EULECHRIA NEBRITIS* Meyr., *ibid.*, 4, 162 (Gisborne).

569. *EULECHRIA CIRRIHOPELA* Turn., *P.L.S.N.S.W.*, 1916, 354 (Darwin).

570. *EULECHRIA NIPHOGRAMMA* Turn., *ibid.*, 1916, 354 (Glen Innes).

571. †*EULECHRIA HELIOCOMA* Meyr., *ibid.*, 1887, 948 (Duarlinga).

572. †*EULECHRIA ALOPECISTIS* Meyr., *ibid.*, 1888, 1565 (Melbourne).

573. *EULECHRIA SYNCHROA* Turn., *ibid.*, 1916, 353 (Glen Innes).

574. †*EULECHRIA HOMOTELES* Meyr., *ibid.*, 1887, 947 (Duarlinga).

575. *EULECHRIA CONCOLOR* Turn., *Tr.R.S.S.Aust.*, 1898, 206 (= *aphanospila* Turn., *P.L.S.N.S.W.*, 1916, 353) (Warwick, Stanthorpe, Glen Innes, Bathurst).

Palpi with second joint exceeding base of antennae, slender, but slightly expanded with loose scales towards apex; terminal joint one-half. Antennal ciliations of male two-thirds.

576. *EULECHRIA HOMOPHANES*, n. sp. (*ὁμοφανης*, uniform.)

♂. 26 mm. Head, thorax, abdomen, and legs pale brown. Palpi with second joint exceeding base of antennae, rather stout and smooth-scaled throughout;

terminal joint three-fourths; brown. Antennae grey; ciliations of male one-half. Forewings elongate-oval, costa strongly arched, apex rounded, termen very obliquely rounded; pale brown; cilia pale brown. Hindwings and cilia grey.

Larger than *E. concolor*, from which it may be distinguished by the different palpi.

Victoria: Gisborne; one specimen received from Mr. Geo. Lyell.

577. *EULECHRIA SIMILIS*, n. sp. (*similis*, like.)

♂. 15 mm. Head and thorax brown. Palpi with second joint reaching base of antennae, terminal joint three-fourths; brown. Antennae brown; ciliations in male 2½. Abdomen brown. Legs brown; posterior pair ochreous-whitish. Forewings elongate, rather narrow, costa gently arched, apex round-pointed, termen nearly straight, oblique; pale brown; cilia pale brown. Hindwings with 5 from middle of cell; dark brown; cilia brown.

Extremely similar to *E. concolor*, distinct by the longer antennal ciliations (in *concolor* less than 1).

North Queensland: Stannary Hills near Herberton; one specimen received from Dr. T. Bancroft.

578. *EULECHRIA HOMOPHYLA*, n. sp. (*ὁμοφυλος*, akin.)

♂. 24 mm. Head and thorax greyish-brown. Palpi with second joint exceeding base of antennae, slender, but slightly thickened and roughened anteriorly towards apex, terminal joint one-half; fuscous, extreme apex of second joint whitish. Antennae grey; ciliations in male 1. Abdomen fuscous-brown; apices of segments and tuft grey. Legs fuscous; posterior pair whitish-ochreous. Forewings elongate, costa moderately arched, apex pointed, termen very obliquely rounded; greyish-brown; stigmata scarcely perceptible, first discal at one-third, plical beneath it, second discal at two-thirds, a dot above and between discals; cilia pale greyish-brown, on tornus grey. Hindwings and cilia fuscous.

Larger than *E. concolor*, the hindwings darker, terminal joint of palpi shorter, and antennal ciliations distinctly longer. *E. homoteles*, which I have not seen, should be distinguishable by the whitish head and antennae.

North Queensland: Ayr in June; one specimen.

579. *EULECHRIA HAPLOSTOLA*, n. sp. (*ἀπλοστολος*, in simple robe.)

♂. 26 mm. Head and thorax whitish-brown. Palpi with second joint exceeding base of antennae, terminal joint one-half; whitish-grey. Antennae whitish-grey; ciliations in male 1½. Abdomen ochreous-grey-whitish. Legs fuscous; posterior pair ochreous-grey-whitish. Forewings elongate, costa gently arched, apex round-pointed, termen very obliquely rounded; whitish-brown; cilia grey-whitish. Hindwings and cilia grey-whitish.

Very like *E. homophanes*, but paler, terminal joint of palpi shorter, and antennal ciliations much longer.

New South Wales: Glen Innes in March; one specimen.

580. *EULECHRIA PERIXANTHA* Turn., *Tr.R.S.S.Aust.*, 1896, 24 (Brisbane, Toowoomba, Tweed Heads, Macpherson Range).

581. *EULECHRIA CEPHALANTHES* Meyr., *P.L.S.N.S.W.*, 1887, 949 (Albany, W.A.).

582. *EULECHRIA XIPHERES* Turn., *Tr.R.S.S.Aust.*, 1896, 23 (Yeppoon to Macpherson Range).

583. *EULECHRIA SCYTHROPA* Meyr., *P.L.S.N.S.W.*, 1883, 339 (= *lithodora* Low., *Tr.R.S.S.Aust.*, 1893, 178) (Caloundra to Tasmania. Mt. Lofty).

584. *EULECHRIA BLOSYRODES*, n. sp. (*βλοσυρωδης*, grim.)

♂, ♀. 21-26 mm. Head, thorax, abdomen, and legs fuscous. Palpi with second joint exceeding base of antennae, terminal joint three-fifths; fuscous. Antennae



fuscous; ciliations in male 1. Forewings elongate-oval, costa moderately arched, apex pointed, termen extremely oblique; fuscous uniformly irrorated with grey-whitish, appearing dark grey; cilia fuscous. Hindwings elongate-ovate, rather narrow; apex pointed; grey; cilia grey.

Very sombre but very distinct from any other species.

Victoria: Kiata near Dimboola (C. Borch); seven specimens.

585. *EULECHRIA SERICOPA* Low., P.L.S.N.S.W., 1915, 482 (Broken Hill).

586. †*EULECHRIA HYPERCHLORA* Meyr., *ibid.*, 1887, 962 (York, Geraldton, W.A.).

587. *EULECHRIA CHLORELLA* Meyr., *ibid.*, 1882, 526 (= *byrsoschra* Meyr., *Exot. Micro.*, i, 301) (Sydney, Bulli).

588. *EULECHRIA SEMANTICA* Turn., P.L.S.N.S.W., 1916, 358 (Mt. Tambourine, Macpherson Range).

589. *EULECHRIA GYPSOMICTA*, n. sp. (γυψομικτος, chalky.)

♂. 20 mm. Head white. Palpi with second joint reaching base of antennae, terminal joint three-fifths; white. Antennae whitish with blackish annulations; ciliations in male 1. Thorax white; anterior edge narrowly fuscous. Abdomen grey; tuft whitish. Legs whitish; anterior pair fuscous. Forewings dilated, costa moderately arched, apex rounded, termen slightly rounded, slightly oblique, white with slight patchy fuscous suffusion; a fuscous spot on base of costa, and a larger spot slightly beyond; discal dots at one-third and before two-thirds with an additional dot between them, all small and obscure; plical slightly before first discal; a large fuscous spot on four-fifths costa; a fuscous line from five-sixths costa, inwardly oblique, sharply angled and continued near termen to tornus; cilia grey-whitish. Hindwings and cilia white.

North Queensland: Kuranda in October. Queensland: National Park (3,000 feet) in November. Two specimens.

590. *EULECHRIA ANOMOPHANES* Turn., *P.R.S.Tas.*, 1926, 144 (Mt. Wellington).

591. *EULECHRIA HABROPHANES* Meyr., P.L.S.N.S.W., 1882, 532 (Stanthorpe to Melbourne. Tasmania).

592. *EULECHRIA PORCHIELLA* Meyr., *ibid.*, 1882, 531 (Sydney to Melbourne. Tasmania. Mt. Lofty).

593. *EULECHRIA FERVESCENS*, n. sp. (*fervescens*, warm in colouring.)

♂, ♀. 18-21 mm. Head white. Palpi with second joint reaching base of antennae, terminal joint three-fifths; white with more or less patchy fuscous suffusion, external surface of terminal joint fuscous. Antennae fuscous. Thorax dark fuscous; outer edge and apex of tegulae white. Abdomen brownish-fuscous. Legs fuscous with whitish rings; posterior pair mostly whitish. Forewings narrow, suboblong, costa nearly straight, apex pointed, termen oblique; dark fuscous; markings white; a narrow costal and a broad median basal streak, both short; a broad transverse fascia just before middle, interrupted in middle; a triangular spot on three-fourths costa; a terminal line not reaching tornus; cilia white with some fuscous bars, apices grey, on tornus wholly grey. Hindwings ochreous-bronzy with slight fuscous suffusion towards apex and termen; cilia grey.

Queensland: Maryland, N.S.W., near Stanthorpe in November; Toowoomba in September; three specimens received from Mr. W. B. Barnard, who has the type.

594. *EULECHRIA LEUCOPELTA* Meyr., P.L.S.N.S.W., 1882, 530 (Stanthorpe to Mittagong).

595. *EULECHRIA STEPHANOTA*, n. sp. (στέφανοτος, crowned.)

♂. 20-22 mm. Head white more or less tinged with brownish-ochreous. Palpi with second joint reaching base of antennae, terminal joint three-fifths; fuscous. Antennae fuscous; ciliations in male one-half. Thorax fuscous with a central

grey-whitish spot. Abdomen fuscous. Legs fuscous; posterior pair grey. Forewings elongate, costa strongly arched, apex rounded, termen very oblique; fuscous with more or less patchy whitish suffusion; sometimes a basal whitish blotch not reaching costa; a dark fuscous costal streak from base to near middle; stigmata dark fuscous, first discal at one-fourth, plical shortly beyond, second discal at three-fifths, double, a dot between and above discals; second discal sometimes connected by dark suffusion with costa and tornus; sometimes a whitish costal spot at four-fifths; a terminal series of dark fuscous dots; cilia grey. Hindwings and cilia grey.

Victoria: Moe in February; two specimens.

596. †*EULECHRIA BRONTOMORPHA* Meyr., P.L.S.N.S.W., 1882, 535 (Sydney).

597. *EULECHRIA ORTHOLOMA*, n. sp. (*ὀρθολωμος*, straight-edged.)

♂. 30 mm. Head and thorax grey-whitish. Palpi with second joint not quite reaching base of antennae, terminal joint one-half; pale grey. Antennae pale grey; ciliations in male 1. Abdomen ferruginous; apices of segments and tuft grey. Legs grey. Forewings elongate, rather narrow, costa straight from near base almost to apex, apex round-pointed, termen very oblique; grey-whitish; cilia grey-whitish. Hindwings with 5 from below middle; pale grey; cilia pale grey, on tornus and dorsum whitish.

Queensland: Duaringa; one specimen received from Mr. W. B. Barnard.

598. *EULECHRIA EPICHRISTA*, n. sp. (*ἐπιχριστος*, anointed.)

♂, ♀. 25-30 mm. Head and thorax ochreous-whitish; sides of face fuscous. Palpi with second joint much exceeding base of antennae, three times length of face, terminal joint three-fifths; fuscous, inner surface and apex of second joint and base of terminal joint whitish. Antennae grey, towards base whitish; ciliations in male two-thirds. Abdomen grey. Legs fuscous; posterior pair, except tarsi, ochreous-whitish. Forewings elongate, slightly dilated, costa gently arched, apex round-pointed, termen very oblique; glossy whitish; costal edge blackish in basal fourth; cilia whitish. Hindwings with 5 from about middle; grey; cilia whitish.

Considerably larger than *E. leucophanes*, the forewings less strongly dilated, the hindwings darker, and the antennal ciliations rather shorter.

Western Australia: Kalamunda near Perth in December: six specimens received from Mr. W. B. Barnard, who has the type.

599. *EULECHRIA OXYPTILA*, n. sp. (*ὀξύπτελος*, sharp-winged.)

♂. 25-26 mm. Head and thorax ochreous-whitish. Palpi with second joint reaching base of antennae, terminal joint three-fifths; ochreous-whitish. Antennae grey, towards base ochreous-whitish; ciliations in male slightly more than 1. Abdomen ochreous-brown; apices of segments and tuft grey-whitish. Legs ochreous-whitish; anterior pair, except coxae, fuscous. Forewings elongate, costa slightly arched; apex pointed, termen very obliquely rounded; whitish; costal edge near base fuscous; cilia whitish. Hindwings whitish-grey; cilia whitish.

Best distinguished from *E. epichrista* by the palpi.

North Queensland: Stannary Hills near Herberton; two specimens received from Dr. T. Bancroft.

600. *EULECHRIA PSAROPHANES* Turn., P.L.S.N.S.W., 1916, 352 (Stanthorpe, Glen Innes, Ebor).

601. *EULECHRIA CALAMAEA* Meyr., *ibid.*, 1883, 492 (Toowoomba, Bunya Mts., Glen Innes).

602. *EULECHRIA CRETACEA* Meyr., *ibid.*, 1883, 491 (Murrurundi, Newcastle, Sydney, Mittagong).

603. *EULECHRIA DELOCHORDA* Turn., *Tr.R.S.N.Aust.*, 1917, 58 (Toowoomba).

604. †*EULECHRIA RUINOSA* Meyr., *Exot. Micro.*, 1, 157 (Q.).  
 605. *EULECHRIA XYLPTERELLA* Meyr., P.L.S.N.S.W., 1882, 543 (Brisbane to Melbourne. Launceston).  
 606. *EULECHRIA ENCRATODES* Meyr., *Exot. Micro.* ii, 510 (Killarney, Stanthorpe. Dorrigo. Gisborne).  
 607. *EULECHRIA DIASSTICHA*, n. sp. (*διαστικός*, with a streak right through.)

♀. 22 mm. Head white. Palpi with second joint exceeding base of antennae, terminal joint 1; whitish, slight fuscous suffusion on outer surface of second joint, terminal joint fuscous anteriorly. Antennae grey, becoming whitish towards base. Thorax white; some fuscous scales on tegulae. Abdomen whitish; median segments except apices grey. Legs whitish; anterior tibiae and tarsi fuscous. Forewings narrow, not dilated, costa slightly arched, apex obtusely pointed, termen very obliquely rounded; white; markings dark fuscous; a narrow streak from base nearly to apex just above middle, its median portion indistinctly double; a series of dots close to apical part of costa and termen; cilia white. Hindwings whitish-grey; cilia whitish.

Queensland: Toowoomba in September; one specimen received from Mr. W. B. Barnard, who has the type.

608. *EULECHRIA TANYSTICHA*, n. sp. (*τανυστικός*, long-streaked.)

♂, ♀. 20-21 mm. Head and thorax pale grey. Palpi with second joint exceeding base of antennae, terminal joint three-fourths; whitish, an oblique ring on middle of second joint, and base and apex of terminal joint, dark fuscous. Antennae pale grey; ciliations in male two-thirds. Abdomen brownish; apices of segments and tuft pale grey. Legs whitish-grey; anterior pair fuscous. Forewings elongate-oval, costa moderately arched, apex pointed, termen very obliquely rounded; whitish-grey; markings and some scattered scales brownish-fuscous; some denser irroration towards base; stigmata blackish, first discal at one-fourth, plical beneath it, second discal at middle, discals united by a dark streak, an additional dot between and above discals; ill-defined streaks in terminal area parallel to veins; a series of longitudinally elongate dots on termen and on costa before apex; cilia grey-whitish with some fuscous points. Hindwings grey; towards base whitish; cilia grey, on tornus and dorsum whitish.

Queensland: National Park (3,000 feet) in October and November; Stanthorpe in October; four specimens received from Mr. W. B. Barnard.

609. *EULECHRIA DYSOLLETA*, n. sp. (*δυσκολλητος*, incongruous.)

♂. 22 mm. Head brown-whitish sprinkled with fuscous. Palpi with second joint much exceeding base of antennae, thickened and rough anteriorly, terminal joint three-fourths; fuscous mixed with brown-whitish. Antennae fuscous; ciliations in male 1. Thorax fuscous; tegulae partly brown. Abdomen brown-whitish. Legs fuscous with brown-whitish rings; posterior pair mostly brown-whitish. Forewings rather narrow, not dilated, costa slightly arched; apex rounded, termen obliquely rounded; pale brown; markings fuscous; a broad costal streak to one-fourth; a sub-basal dorsal blotch anteriorly rectangular, upper posterior angle with a short stout oblique process, which is really the first discal stigma; a triangular mark on costa before middle, its apex formed by second discal; a suboblong blotch on costa before apex, giving off a line running to tornus close to termen; cilia brown, bases with obscure fuscous bars, apices grey. Hindwings pale grey; cilia ochreous-whitish.

Western Australia: Collie in October; type in Coll. Lyell.

610. *EULECHRIA ACERVATA* Meyr., *Exot. Micro.*, 1, 161 (Perth, Waroona, W.A.).

611. *EULECHRIA AERODES* Meyr., P.L.S.N.S.W., 1883, 321 (Bathurst, Gisborne, Tasmania).  
 612. *EULECHRIA LEPTOCHORDA* Turn., *ibid.*, 1916, 354 (Magnetic Is.).  
 613. *EULECHRIA ANTYGOTA* Meyr., *Exot. Micro.*, 1, 161 (Perth, Waroona, W.A.).  
 614. *EULECHRIA HOMOXESTA* Meyr., P.L.S.N.S.W., 1887, 965 (Guildford, Waroona, W.A.).

615. †*EULECHRIA HOMOCHALCHA* Meyr., *ibid.*, 1887, 965 (York, W.A.).

616. *EULECHRIA HOLOPSARA*, n. sp. (*δολοψαρος*, wholly grey.)

♂, ♀. 20–22 mm. Head and thorax grey; in female tinged brownish. Palpi slender, in male with second joint exceeding base of antennae, terminal joint one-half, in female with second joint shorter, terminal joint three-fifths; grey. Antennae grey; ciliations in male 1. Abdomen brownish-grey. Legs grey; posterior pair ochreous-whitish. Forewings elongate, narrow, costa gently arched, more strongly in female, apex pointed, termen extremely oblique; grey, in female brownish-tinged; some scattered fuscous scales; stigmata obsolete or minute, first discal at one-third, plical beneath it, second discal at two-thirds, a dot beneath second discal; cilia grey. Hindwings and cilia grey.

A very obscure species. The very narrow elongate forewings and comparatively short palpi should be noted.

Queensland: Talwood in April; eight specimens received from Mr. W. B. Barnard, who has the type.

617. *EULECHRIA THRINCOTIS* Meyr., P.L.S.N.S.W., 1887, 965 (Cunderdin, Geraldton, W.A.).

618. †*EULECHRIA HALMOPEDA* Meyr., *ibid.*, 1887, 963 (Carnarvon, W.A.).

619. *EULECHRIA FRIGESCENS* Meyr., *Exot. Micro.*, 1, 160 (Mt. St. Bernard).

620. *EULECHRIA PULVIFERA*, n. sp. (*pulviferus*, powdered.)

♂. 22 mm. ♀. 25 mm. Head and thorax pale grey. Palpi with second joint exceeding base of antennae, terminal joint one-half; whitish-grey. Antennae grey; ciliations in male 3. Abdomen pale grey; bases of segments fuscous. Legs grey; posterior pair whitish-grey. Forewings very elongate and narrow, costa moderately arched, apex pointed, termen obliquely rounded; ochreous-whitish sprinkled with grey; an outwardly curved grey line from four-fifths costa to tornus; some grey terminal dots; cilia pale grey. Hindwings and cilia grey-whitish.

Queensland: Southport in July; two specimens received from Mr. W. B. Barnard, who has the type.

621. *EULECHRIA LEPTOCHROMA*, n. sp. (*λεπτοχρῶμος*, lightly coloured.)

♀. 22 mm. Head and thorax whitish-grey. Palpi with second joint exceeding base of antennae, terminal joint four-fifths; whitish, outer surface of second joint except base and apex fuscous. Antennae grey, near base whitish. Abdomen ochreous-grey-whitish. Legs whitish; anterior pair fuscous. Forewings narrow, costa gently arched, apex pointed, termen very obliquely rounded; whitish-grey faintly pinkish-tinged, sparsely sprinkled with fuscous; veins slenderly whitish; cilia whitish, bases faintly pinkish-tinged. Hindwings pale grey; cilia whitish.

Queensland: Macpherson Range (2,500 feet in open forest) in November; one specimen.

622. *EULECHRIA JUGATA* Meyr., *Exot. Micro.*, 1, 161 (Kerang, V.).

623. *EULECHRIA SEMNOSTOLA* Low., *Tr.R.S.S.Aust.*, 1901, 90 (Broken Hill).

624. *EULECHRIA STYRACISTA* Meyr., *Exot. Micro.*, 11, 370 (Hobart).

625. *EULECHRIA PHAEOCEPTRA* Meyr., P.L.S.N.S.W., 1887, 964 (Waroona, Geraldton, W.A.).

626. *EULECHRIA CALLISCEPTRA* Meyr., *ibid.*, 1887, 964 (Perth, York, Cunderdin, Geraldton, W.A.).

627. *EULECHRIA COSMOCRATES* Meyr., *ibid.*, 1888, 1615 (= *dulcescens* Meyr., *Exot. Micro.*, 1, 130) (Atherton, Duaringa, Yeppoon, Tabulam, N.S.W.).

628. *EULECHRIA GYPSOCHROA*, n. sp. (*γυψοχρoος*, chalky.)

♂. 21-22 mm. Head white. Palpi with second joint much exceeding base of antennae,  $2\frac{1}{2}$  times length of face, terminal joint three-fourths; whitish, second joint ochreous-tinged externally. Antennae grey. Thorax blackish; a large posterior spot and bases of tegulae white. Abdomen brownish; apices of segments ochreous-whitish. Legs whitish; anterior pair pale greyish-brown. Forewings elongate-oval, costa moderately arched, apex round-pointed, termen obliquely rounded; white; markings brown; first discal obsolete, plical at one-third, second discal at two-thirds, connected by a coarse line with tornus; a fine interrupted line close to termen from costa before apex to tornus; cilia white. Hindwings ochreous-grey-whitish; cilia whitish.

Queensland: Talwood in November; five specimens received from Mr. W. B. Barnard, who has the type.

629. *EULECHRIA CYCLOPHRAGMA* Meyr., P.L.S.N.S.W., 1888, 1581 (= *holocycla* Low., *Tr.R.S.S.Aust.*, 1894, 98) (Toowoomba to Gisborne).

630. *EULECHRIA PLAGIOSTICHA* Turn., P.L.S.N.S.W., 1916, 355 (= *argyrodes* Turn., *Tr.R.S.S.Aust.*, 1917, 100) (Brisbane).

631. *EULECHRIA INSTRUCTA* Meyr., *Exot. Micro.*, ii, 370 (Dalby).

632. *EULECHRIA PYCNOGRAPHIA* Turn., P.L.S.N.S.W., 1916, 355 (Ebor).

633. *EULECHRIA VARIEGATA* Meyr., *ibid.*, 1882, 528 (Brisbane and Bunya Mts., to Gisborne and Sale).

634. *EULECHRIA HEMIPHANES* Meyr., *ibid.*, 1882, 529 (Melbourne, Launceston).

635. †*EULECHRIA AMPHILEUCA* Low., *Tr.R.S.S.Aust.*, 1903, 222 (Birchip).

636. *EULECHRIA ELAEOTA* Meyr., P.L.S.N.S.W., 1887, 957 (Perth, W.A.).

637. *EULECHRIA CATAPLANTA* Meyr., *ibid.*, 1887, 957 (Denmark, Perth, W.A.).

638. *EULECHRIA PHAECHORDA*, n. sp. (*φαισχoρδος*, dark-streaked.)

♂. 25 mm. Head white. Palpi with second joint reaching base of antennae, terminal joint two-thirds; white, external surface of second joint except apex fuscous. Antennae grey; ciliations in male 6. Thorax fuscous, with some central whitish suffusion. Abdomen grey. Legs fuscous; posterior pair whitish. Forewings somewhat dilated, costa slightly arched, apex pointed, termen very oblique; white; markings dark fuscous; a broad costal streak from base narrowing to a point at three-fifths; a dorsal streak from base, soon dilated to reach half across disc, reaching tornus, its upper edge curved and surmounted by two blackish dots, which are partly confluent with it; a double blackish dot at two-thirds with an outwardly oblique extension to tornus; a large apical blotch containing some small white marks on costa and termen; cilia fuscous. Hindwings and cilia grey.

Tasmania: Bothwell in March; one specimen received from Mr. W. B. Barnard.

639. †*EULECHRIA CEPHALOCHRYSA* Low., *Tr.R.S.S.Aust.*, 1894, 95 (Duaringa).

640. *EULECHRIA CALLIMERIS* Meyr., P.L.S.N.S.W., 1887, 958 (Busselton, Perth, W.A.).

641. *EULECHRIA EGREGIA*, n. sp. (*egregius*, out of the common.)

♂, ♀. 21-24 mm. Head and thorax fuscous with a few whitish scales. Palpi with second joint reaching base of antennae, terminal joint three-fifths; fuscous, second joint with lower and basal part of external surface white. Antennae fuscous, ciliations in male two-thirds. Abdomen whitish-ochreous; bases of segments on dorsum partly fuscous. Legs fuscous on dorsum, white beneath; posterior pair pale ochreous. Forewings subrectangular, costa strongly arched,

apex rounded, termen moderately oblique; grey; a small fuscous basal patch; a dark fuscous costal streak from one-fourth to two-thirds, broadest in middle, diminishing gradually to each extremity; a broad suffused white streak beneath this throughout and continued to apex; a fine fuscous line from three-fourths costa cuts across this and is continued by a fine white line to tornus; stigmata fuscous, minute, first discal at one-third, plical obsolete, second discal at two-thirds; cilia grey with a darker sub-basal line. Hindwings and cilia grey.

New South Wales: Cudgen, Tweed Heads, in October; two specimens received from Mr. W. B. Barnard, who has the type.

642. †EULECHRIA INCHNODES Meyr., *Tr.R.S.N.Aust.*, 1902, 150 (Kewell, V.).

643. EULECHRIA CARBAREA Turn., *ibid.*, 1917, 98 (Atherton).

644. EULECHRIA SCITULA Turn., *ibid.*, 1917, 98 (Tabulam, N.S.W.).

645. †EULECHRIA XANTHOCROSSA Meyr., *P.L.S.N.S.W.*, 1887, 959 (Geraldton, W.A.).

646. EULECHRIA THIOCROSSA Turn., *Tr.R.S.N.Aust.*, 1917, 97 (Gympie to Tweed Heads, Stanthorpe).

647. EULECHRIA TRANSVERSILLA Wlk., *xxix*, 763; Meyr., *P.L.S.N.S.W.*, 1882, 527 (Duarina to Sydney).

648. EULECHRIA PREPODES, n. sp. (*πρεπώδης*, seemly.)

♂. 18-22 mm. Head white, ochreous-tinged. Palpi with second joint reaching base of antennae, terminal joint three-fourths; fuscous, extreme apex of second joint and base of terminal joint whitish. Antennae grey; ciliations in male 1. Thorax ochreous-whitish; bases of tegulae dark fuscous. Abdomen grey; tuft whitish-ochreous. Legs fuscous; posterior pair whitish-ochreous. Forewings sub-oblong, costa slightly arched, apex rounded, termen very obliquely rounded; whitish, more or less ochreous-tinged; markings blackish; a narrow outwardly oblique fascia from base of costa to near base of dorsum, well defined and of uniform thickness; a costal streak from base to two-thirds; stigmata obsolete or represented by two dots placed transversely at two-thirds; a terminal series of dots more or less developed; cilia whitish. Hindwings grey; cilia grey-whitish.

New South Wales: Brunswick Heads in January; two specimens received from Mr. W. B. Barnard.

649. EULECHRIA PAROCRANA, n. sp. (*παροκρανος*, with brown head.)

♂, ♀. 22-26 mm. Head pale brown; centre of crown and face grey-whitish. Palpi with second joint reaching base of antennae, terminal joint four-fifths; fuscous, terminal joint and apex of second whitish. Antennae grey, basal joint fuscous; ciliations in male 1. Thorax pale grey; anterior edge mostly fuscous. Abdomen pale grey; tuft ochreous-whitish. Legs fuscous with whitish rings; posterior pair mostly whitish-ochreous. Forewings rather narrow, suboval; costa moderately arched, apex rounded, termen obliquely rounded; whitish-grey; markings fuscous; a large triangular spot on base of costa; another on midcosta; stigmata small, dark fuscous, first discal at one-fourth, plical beyond it; second discal beyond middle, a dot between and above discals touching apex of midcostal spot, a dot beneath second discal; a short inwardly oblique streak from four-fifths costa, soon angled and continued as a fine curved interrupted line to tornus; cilia grey-whitish with a darker median line. Hindwings whitish-grey; cilia grey-whitish.

Near *E. transversella*, but with brownish head and without complete basal fascia.

Queensland: Brisbane and Gympie in September, Bunya Mts. (3,500 feet) in November. New South Wales: Lismore in October. Eight specimens.

650. *EULECHRIA TRANQUILLA*, n. sp. (*tranquillus*, calm, peaceful.)

♂, ♀. 20–25 mm. Head white or grey-whitish. Palpi with second joint reaching base of antennae, terminal joint three-fourths; grey-whitish; external surface of second joint except apex fuscous. Antennae fuscous; ciliations in male two-thirds. Thorax grey-whitish; anterior edge and bases of tegulae fuscous. Abdomen grey, ferruginous-tinged; apices of segments and tuft grey-whitish. Legs fuscous; posterior pair and dorsum of middle tibiae grey-whitish. Forewings rather narrow, not dilated, costa moderately arched, apex rounded, termen obliquely rounded; grey-whitish; markings and slight irroration fuscous; a very distinct basal fascia; first discal just before one-third, plical slightly beyond it, second discal before two-thirds, a dot midway between and above discals, another just beyond and above plical, a sixth beneath second discal, sometimes obliquely crescentic, sometimes confluent; usually a suffused median costal spot; a short inwardly oblique streak from costa before apex emitting a fine curved line to tornus; cilia whitish-grey. Hindwings elongate-ovate; grey; cilia pale grey.

Near *E. foedatella*, but with narrower forewings, sub-basal fascia entire, straight, and of even thickness, not wedge-shaped, no defined dark costal triangle. It cannot be *E. archepeda*, which I have not seen, for that has antennal ciliations 1½. The dot above and beyond plical distinguishes it from *E. transversella*.

Queensland: Byfield near Yeppoon in October; six specimens.

651. *EULECHRIA PLESIOSPERMA*, n. sp. (*πλησιοςπέρμος*, with approximated spots.)

♂. 21–22 mm. Head brown-whitish. Palpi with second joint reaching base of antennae, terminal joint two-thirds; fuscous, extreme apex of second joint whitish. Antennae pale grey; ciliations in male three-fourths. Thorax whitish-grey; bases of tegulae fuscous. Abdomen fuscous irrorated with grey-whitish; apices of segments and tuft grey-whitish. Legs fuscous with ochreous-whitish rings; posterior pair ochreous-whitish. Forewings with costa moderately arched, apex round-pointed, termen very obliquely rounded; grey-whitish with some grey suffusion and scanty fuscous irroration; markings fuscous; an outwardly oblique quadrate spot from base of costa to fold; stigmata nearly approximated, first discal at two-fifths, plical beneath it, second discal at three-fifths, a dot above and between discals, another above and beyond plical, a sixth beneath second discal, and a seventh beneath and before sixth; suffused spots on two-thirds and five-sixths costa sometimes suffusedly connected with mid-dorsum; a terminal series of dots; cilia grey-whitish, bases ochreous-whitish.

Queensland: Malanda, Atherton Plateau, in September; two specimens.

652. *EULECHRIA NAPAEA* TURN. *Tr.R.S.S.Aust.*, 1917, 99.

This is certainly very similar to *E. foedatella* Meyr., and is best distinguished by the shorter antennal ciliations, one-half in the former, 1 in the latter. In *E. napaea* the first discal (at one-fourth) is nearly always closely followed by a dot beyond and beneath; this is absent in *E. foedatella*.

(Brisbane, Rosewood, Mt. Tambourine, Macpherson Range.)

653. *EULECHRIA FOEDATELLA* MEYR., *P.L.S.N.S.W.*, 1883, 377 (Eungella to Sydney).654. †*EULECHRIA ARCHPEDA* MEYR., *ibid.*, 1887, 960 (Sydney).655. *EULECHRIA TRIGONOSEMA*, n. sp. (*τριγωνόσημος*, with triangular markings.)

♂, ♀. 22–26 mm. Head whitish-ochreous; in female grey. Palpi with second joint reaching base of antennae, terminal joint three-fifths; fuscous, extreme apex of second joint and base of terminal joint ochreous-whitish. Antennae grey; ciliations in male 1. Thorax fuscous, apices of tegulae and a posterior spot ochreous-whitish. Abdomen fuscous; tuft whitish-ochreous. Legs fuscous; posterior pair whitish-ochreous. Forewings rather broad, costa strongly arched,

apex rounded, termen moderately oblique; whitish or ochreous-whitish with some fuscous sprinkling; markings fuscous; a small triangle on base of costa; another on costa just before middle, somewhat equilateral; stigmata dot-like, first discal at one-fourth, plical slightly beyond, second discal at three-fifths, a dot between and above discals touching median triangle, and two conjoined dots beneath second discal; a line from three-fourths costa, at first transverse, then bent outwards and curved inwards to tornus; a terminal series of dots; cilia whitish with a pale fuscous median line. Hindwings and cilia grey.

Queensland: Macpherson Range in November; six specimens.

656. *EULECHRIA STHENOPSIS* Turn., *P.R.S.Tas.*, 1926, 145 (Mt. Wellington, Cradle Mt., Strahan).

657. *EULECHRIA HYPOPOLIA* Turn., *Tr.R.S.S.Aust.*, 1917, 99 (Stanthorpe to Scone).

658. *EULECHRIA HETAEIRICA*, n. sp. (*ἑταιρικός*, a companion.)

♂. 24-26 mm. Head pale grey. Palpi with second joint reaching base of antennae, terminal joint three-fifths; fuscous, extreme apex of second and base of terminal joint whitish. Antennae pale grey; ciliations in male 1½. Thorax whitish; bases of tegulae fuscous. Abdomen grey-whitish; bases of segments ferruginous-fuscous. Legs fuscous with whitish rings; posterior pair ochreous-whitish. Forewings elongate, costa strongly arched, apex rounded, termen obliquely rounded; grey-whitish; markings and some irroration fuscous; a triangular spot on base of costa reaching fold; another on midcosta less distinctly developed; first discal about one-third, plical beneath it, second discal not much beyond middle, a dot above and between discals, another beneath second; a slender line from five-sixths costa, bent outwards beneath costa, then downwards and curved to tornus; a terminal series of dots; cilia whitish, a suffused interrupted grey line before middle. Hindwings and cilia whitish-grey.

Very like *E. trigonosema*, but the forewings are longer and in proportion narrower, less distinctly marked, and the antennal ciliations substantially longer.

North Queensland: Kuranda in September; five specimens.

659. *EULECHRIA MACHINOSA* Meyr., *Exot. Micro.*, 1, 159 (Dorrigo, Ebor).

660. *EULECHRIA PLACOPHAEA*, n. sp. (*πλακοφαίος*, broadly fuscous.)

♂. 22 mm. Head pale ochreous. Palpi with second joint just reaching base of antennae, terminal joint three-fourths; fuscous, base and extreme apex of second joint whitish. Antennae dark grey; ciliations in male 1. Thorax fuscous. (Abdomen missing.) Legs fuscous; posterior pair ochreous-whitish. Forewings with costa moderately arched, apex round-pointed, termen obliquely rounded; white irrorated and suffused with fuscous; markings dark fuscous, broadly developed; a broad streak from base of costa to fold, acutely toothed in middle and at apex, continued by a broad bar along dorsum to middle, and touching plical dot; a costal triangle from one-fifth to three-fifths, its apex rather posterior; first discal before one-third, touching costal triangle, plical beneath it, second discal forming a crescentic transverse mark before two-thirds, a dot beyond and above plical; a large spot on costa before apex giving rise to an outwardly curved line and an inwardly curved suffusion, which meet at tornus; a terminal series of dots; cilia grey-whitish with a sub-basal series of fuscous bars. Hindwings grey-whitish, towards apex pale grey; cilia pale grey, on tornus and dorsum ochreous-whitish.

Queensland: Toowoomba in September; one specimen.

661. †*EULECHRIA MATHEMATICA* Meyr., *P.L.S.N.S.W.*, 1883, 375 (Sydney).

662. *EULECHRIA CIRRHOCEPHALA* Turn., *Tr.R.S.S.Aust.*, 1917, 96 (Brisbane, Macpherson Range).



663. *EULECHRIA CAPNOPLEURA*, n. sp. (καπνοπλευρος, with smoky costa.)

♂, ♀. 25-30 mm. Head whitish-brown. Palpi with second joint reaching base of antennae, terminal joint three-fourths; grey, base and apex of second joint whitish. Antennae pale grey; ciliations in male 1. Thorax grey. Abdomen ferruginous; apices of segments and tuft ochreous-whitish. Legs ochreous-whitish; anterior pair fuscous. Forewings suboval, costa rather strongly arched, apex pointed, termen oblique; whitish, with patchy grey suffusion; markings fuscous; a darker basal spot produced to fold; a broadly suffused costal streak from near base to three-fifths; first discal at one-third, plical beyond it, second discal before two-thirds, a fourth dot above and slightly beyond plical, a fifth midway above and between discals, confluent with costal streak, a sixth beneath second discal, usually confluent with it to form a semilunar mark, in one example this is much prolonged to include fourth dot; a much suffused broad inwardly oblique streak from four-fifths costa to middle of disc; from its outer edge proceeds a fine strongly curved line to tornus; a series of minute terminal dots; cilia pale grey, apices whitish. Hindwings with 5 from middle or slightly below; whitish; apex with slight grey suffusion; cilia whitish.

Very similar to Meyrick's description of *E. dedecorata*, but in that species the antennal ciliations are nearly 2, and the dot above and beyond plical is absent.

Queensland: Mt. Tambourine in September, October; National Park (2,500 to 3,500 feet) in October, November and December; nine specimens.

664. †*EULECHRIA DEDECORATA* Meyr., *Exot. Micro.*, 1, 302 (Duaringa).665. *EULECHRIA PERIOECA*, n. sp. (περιοικος, neighbouring.)

♂. 22 mm. Head brown-whitish. Palpi with second joint exceeding base of antennae, terminal joint three-fifths; brown-whitish. Antennae pale grey; ciliations in male 2½. Thorax fuscous. Abdomen ochreous-whitish, towards base of dorsum greyish-tinged. Forewings rather narrow, costa moderately arched, apex round-pointed, termen obliquely rounded; ochreous-whitish with a few fuscous scales, but no fuscous suffusion; markings fuscous; a slender suffused bar from base of costa obliquely outwards to fold; a suffused costal mark thickest in middle and tapering at each end to costa at one-third and two-thirds; first discal at one-fourth, plical distinctly beyond it, second discal before two-thirds, a dot between and above discals touching costal mark, a dot beneath second discal prolonged inwards to form a short slender streak, a dot above and beyond discal, not near it, but almost beneath fourth dot; a slender line from four-fifths costa, at first shortly inwards, then curved outwards and ending near tornus; a series of minute dots on termen and terminal part of costa; cilia ochreous-whitish. Hindwings pale grey; cilia grey-whitish.

Not unlike *E. capnopleura*, from which it is distinguished by the antennal ciliations, which are even longer than in *E. dedecorata*. From the latter it differs in the fuscous thorax, wholly brown-whitish palpi, and in the presence of a dot beyond plical and almost beneath fourth dot.

Queensland: Rosewood in April; one specimen.

666. *EULECHRIA PASTEOPTERA*, n. sp. (παστεοπτερος, with peppered wings.)

♂, ♀. 24-26 mm. Head ochreous-whitish. Palpi with second joint much exceeding base of antennae (twice length of face), terminal joint one-half; ochreous-whitish. Antennae pale grey; ciliations in male 1. Thorax whitish sprinkled with grey. Abdomen ochreous-whitish; bases of segments ferruginous. Legs whitish-ochreous; anterior pair grey. Forewings rather narrow, costa gently arched, apex pointed, termen very oblique; ochreous-whitish with some fuscous irroration within cell and towards margins; an oblique fascia from near base of

costa indistinct beneath fold; a fuscous costal streak from one-fourth to middle; stigmata dark fuscous, first discal at one-fourth, plical beyond it, second discal at three-fourths, a fourth dot just above and beyond plical, a fifth midway between and above discals, a sixth sometimes double beneath second discal; cilia whitish. Hindwings with 5 from below middle; whitish; cilia whitish.

Very near *E. capnopleura*, but the difference in palpi appears conclusive.

North Queensland: Cairns in June; Cardwell in August; two specimens.

667. *EULECHRIA XUTHOCRANA*, n. sp. (*ξουθοκρανος*, with yellowish head.)

♂. 19-21 mm. Head pale ochreous. Palpi with second joint reaching base of antennae, terminal joint three-fifths; ochreous-fuscous. Antennae ochreous-grey; ciliations in male two-thirds. Thorax grey. Abdomen ferruginous; apices of segments whitish-grey; tuft whitish-ochreous. Legs fuscous; posterior pair whitish-ochreous. Forewings suboblong, costa rather strongly arched, apex rounded, termen obliquely rounded; 2 and 3 connate; ochreous-whitish sprinkled with fuscous, more densely towards margins; central area nearly clear; a suffused basal transverse fascia; stigmata dark fuscous, distinct, first at one-fourth, plical beneath it, sometimes elongate, second discal just beyond middle, a fourth dot between and above discals, a fifth beneath second discal; usually a broad fuscous suffusion on mid-dorsum; a line from costa before apex bent in disc and ending in tornus; some indistinct terminal dots; cilia ochreous-whitish, bases with fine fuscous bars. Hindwings with 5 from middle or below; grey-whitish slightly darker towards apex; cilia grey-whitish.

North Queensland: Millaa Millaa in September. Queensland: Bundaberg; Bunya Mts. in October; Mt. Tambourine in October and November. New South Wales: Lismore in October; Bulli. Nine specimens.

668. *EULECHRIA MELICHTA*, n. sp. (*μελιχίτος*, honey-stained.)

♂. 16-18 mm. ♀. 20-22 mm. Head orange-ochreous. Palpi with second joint reaching base of antennae, terminal joint three-fifths; fuscous, apex of second and base of terminal joint whitish. Antennae fuscous; ciliations in male  $1\frac{1}{2}$ . Thorax fuscous; posterior edge and apices of tegulae ochreous. Abdomen grey; tuft whitish-ochreous. Legs fuscous with whitish tarsal rings; posterior pair whitish-ochreous. Forewings rather narrow, costa gently arched, apex round-pointed, termen very obliquely rounded; pale ochreous, sometimes with a few scattered fuscous scales; markings fuscous; a short streak on base of costa; stigmata small, sometimes partly obsolete; first discal at one-third, plical beyond, second discal before two-thirds, a dot above and between discals; sometimes a suffused subapical spot giving origin to a fine subterminal line; cilia pale ochreous. Hindwings grey; cilia pale grey, bases ochreous-tinged.

Queensland: Macpherson Range (Binna Burra, 2,500 feet) in December; six specimens.

669. *EULECHRIA MYROCHIRISTA* Meyr., *Exot. Micro.*, ii, 371 (Nambour to Dorrigo).

670. *EULECHRIA THIOPAPHES*, n. sp. (*θειοπαφης*, suffused with sulphur.)

♂. 19-20 mm. Head orange-ochreous. Palpi with second joint reaching base of antennae, terminal joint three-fifths; fuscous, base of terminal joint whitish. Antennae dark fuscous; ciliations in male 1. Thorax pale ochreous; bases of tegulae dark fuscous. Abdomen grey; apices of segments ochreous-whitish; tuft pale ochreous. Legs fuscous; posterior pair whitish-ochreous. Forewings narrow, costa slightly arched, apex round-pointed, termen oblique, whitish-ochreous; markings dark fuscous; a broad costal streak from base gradually attenuating to three-fourths; discals approximated, first discal beyond one-third, plical before it

or obsolete, second discal before two-thirds, transversely elongate, a dot between and above discals; a short inwardly oblique streak from costa before apex; some minute terminal dots; cilia orange-ochreous. Hindwings and cilia pale grey.

Queensland: Macpherson Range in December; two specimens. My second example has tegulae wholly dark fuscous and costal streak prolonged at base to reach dorsum.

671. *EULECHRIA PACHYCHORDA*, n. sp. (παχυχορδος, thick-streaked.)

♀. 20 mm. Head whitish. Palpi with second joint reaching base of antennae, terminal joint two-thirds; whitish. Antennae dark fuscous. Thorax dark fuscous. Abdomen pale grey. Legs ochreous-whitish; anterior pair fuscous. Forewings rather narrow, costa gently arched, apex pointed, termen oblique; whitish; markings dark fuscous; a broad costal streak from base nearly to apex; first discal at one-third, plical beneath it, second discal forming a short transverse mark at two-thirds, a dot above and between discals touching costal streak; some fuscous irroration on termen; cilia whitish. Hindwings and cilia pale grey.

Queensland: National Park (2,500 feet) in March; one specimen.

672. *EULECHRIA BASICAPNA*, n. sp. (βασικαννος, smoky at the base.)

♂. 16 mm. Head whitish-ochreous. Palpi with second joint just reaching base of antennae, terminal joint three-fourths; whitish, external surface of second joint except apex fuscous. Antennae fuscous; cillations in male 1. Thorax whitish; putagia whitish-ochreous; tegulae fuscous. Abdomen grey, apices of segments paler; tuft whitish-ochreous. Legs ochreous-whitish; anterior pair fuscous. Forewings suboblong, costa strongly arched near base, thence straight to near apex, apex rounded, termen obliquely rounded; whitish; markings and some scattered scales fuscous; a sharply defined basal fascia extending further on costa than dorsum; a suffused streak from above middle of disc shortly beyond base to three-fifths costa; two adjacent dots placed transversely in disc at three-fourths; a spot on four-fifths costa giving origin to outwardly and inwardly curved lines, which join shortly above and are continued to tornus; a terminal series of dots; cilia whitish, bases whitish-ochreous, with a grey antemedian line. Hindwings grey; cilia grey-whitish.

New South Wales: Brunswick Heads in December; three specimens received from Mr. W. B. Barnard, who has the type.

673. *EULECHRIA HEXASTICTA*, n. sp. (ἑξαστικτος, six-spotted.)

♂. 22-23 mm. Head grey-whitish. Palpi with second joint reaching base of antennae, terminal joint three-fourths; whitish, external surface of second joint except apex pale fuscous. Antennae pale grey; cillations in male 1. Thorax grey; posterior apex and apices of tegulae whitish. Abdomen pale ochreous-grey, partly ferruginous. Legs fuscous; posterior pair ochreous-whitish. Forewings narrow, costa moderately arched, apex pointed, termen very oblique; whitish partly sprinkled with pale fuscous towards dorsum and termen; costal edge fuscous; a fuscous costal streak from one-third to two-thirds; stigmata small, blackish, first discal at one-fourth, plical well beyond it, second discal at three-fifths, a fourth dot immediately above and beyond plical, a fifth midway between and above discals, a sixth sometimes double beneath second discal; cilia whitish. Hindwings with 5 from below middle; pale grey; cilia pale grey, apices whitish.

Queensland: Yeppoon in September; five specimens.

674. *EULECHRIA SYNCOLLA* Turn., *Tr.R.S.S.Aust.*, 1917, 97 (Ebor).

675. *EULECHRIA VICINA* Turn., *P.L.S.N.S.W.*, 1916, 356 (Guyra, Ebor).

676. *EULECHRIA BATHROPHAEA* Turn., *ibid.*, 1914, 562 (Ebor).

677. *EULECHRIA LEUCOSTEPHANA* Turn., *ibid.*, 1916, 356 (Mt. Kosciuszko).

678. *EULECHRIA SYNNEPHES*, n. sp. (*συννεφης*, clouded.)

♂. 18-20 mm. Head whitish. Palpi with second joint just reaching base of antennae, terminal joint three-fourths; whitish, outer surface partly grey-suffused. Antennae pale grey; ciliations in male 1. Thorax whitish anteriorly suffused with grey. Abdomen brown-whitish sprinkled with grey-whitish; apices of segments and tuft grey-whitish. Legs pale fuscous; posterior pair whitish. Forewings suboblong, costa gently arched, apex round-pointed, termen nearly straight, oblique; whitish, partly suffused and sprinkled with pale fuscous; a large basal costal spot; a suffusion on midcosta reaching middle of disc; another inwardly oblique from costa before apex; stigmata minute, first discal at two-fifths, plical beneath it, second discal at two-thirds; some irroration before termen; cilia whitish partly suffused with pale fuscous. Hindwings and cilia whitish-grey.

North Queensland: Kuranda in September; two specimens received from Mr. F. P. Dodd.

679. *EULECHRIA CNECOPASTA*, n. sp. (*κνηκοπαστος*, sprinkled with pale yellow.)

♂. 23 mm. Head and thorax fuscous. Palpi with second joint exceeding base of antennae, twice length of face, terminal joint three-fourths; fuscous, inner surface of second and posterior of terminal joint ochreous-whitish. Antennae grey; ciliations in male 1. Abdomen pale ochreous-grey; tuft whitish-ochreous. Legs fuscous; middle pair partly and posterior pair wholly whitish-ochreous. Forewings elongate-oval, costa strongly arched, apex pointed, termen obliquely rounded; whitish densely sprinkled with whitish, appearing grey; patches of whitish-ochreous suffusion on two-thirds costa and above tornus; markings dark fuscous; an oblique quadrate mark on base of costa; stigmata slightly elongate, first discal at one-third, plical beyond it, second discal before two-thirds, an elongate dot before and beneath plical, one above and between discals, and another beneath second discal; a short inwardly oblique streak from three-fourths costa, giving origin to a fine curved dentate line to tornus; cilia whitish-ochreous with fuscous bars, apices grey. Hindwings and cilia whitish-ochreous.

Queensland: Macpherson Range in December; one specimen.

680. *EULECHRIA PHAEDELTA*, n. sp. (*φαιοδελτος*, with dusky triangle.)

♂. 26 mm. Head ochreous-whitish. Palpi slightly exceeding base of antennae, terminal joint three-fifths; ochreous-whitish mixed with fuscous. Antennae fuscous; ciliations in male 1½. Thorax grey; tegulae except apices fuscous. Abdomen grey; apices of segments whitish; tuft whitish-ochreous. Legs fuscous with obscure pale tarsal rings; posterior tibiae whitish-ochreous. Forewings moderate, costa moderately arched, apex rounded, termen very obliquely rounded; whitish sprinkled with grey; markings fuscous, rather suffused; a sub-basal transverse fascia; a large triangle extending on costa from one-third almost to two-thirds, its apex confluent with first discal at one-third; second discal before two-thirds, a dot above and between discals; a broad dorsal suffusion extending above fold, and thence obliquely to four-fifths costa, this occupies the whole of terminal area, but contains some whitish irroration; cilia pale fuscous. Hindwings elongate-ovate; dark grey; cilia grey.

North Queensland: Magnetic Island in June; one specimen.

681. †*EULECHRIA BRACHYSTOMA* Meyr., *Exot. Micro.*, 1, 299 (Duaringa).

682. *EULECHRIA HEPTASTICTA*, n. sp. (*επταστικτος*, seven-spotted.)

♂. 20 mm. Head whitish-grey. Palpi with second joint reaching base of antennae, terminal joint three-fourths; fuscous; inner surface mostly whitish. Antennae fuscous; ciliations in male one-half. Thorax fuscous. Abdomen grey; tuft whitish-grey. Legs fuscous with whitish rings; posterior pair mostly whitish,

Forewings suboblong, costa strongly arched, apex rounded, termen obliquely rounded; grey; a small oblong dark fuscous blotch on one-third dorsum surrounded by whitish suffusion; stigmata dark fuscous, dot-like, mostly edged with whitish, first discal at one-third, plical slightly beyond, second discal at three-fifths, a dot between discals, another beneath and beyond first, a sixth above and beyond plical, and a seventh beneath second discal; a fuscous line from four-fifths costa curved outwards, then bent and inwardly curved to tornus; a terminal series of dots; cilia pale fuscous. Hindwings and cilia grey.

Queensland: Noosa in October; one specimen.

683. *EULECHRIA CHRYSOLOMA* Low., *Tr.R.S.N.Aust.*, 1893, 179 (Melbourne, Gisborne, Adelaide).

684. *EULECHRIA MEMAMYDRA*, n. sp. (*μεσαμυδρος*, dark in the middle.)

♀. 14 mm. Head whitish-grey. Palpi with second joint reaching base of antennae, terminal joint three-fifths; whitish, base and a subapical ring on second joint, and terminal joint except base, fuscous. Antennae grey. Thorax fuscous. Abdomen grey. Legs fuscous with whitish rings; posterior pair fuscous. Forewings narrow, costa almost straight, apex pointed, termen very oblique; whitish with a few fuscous scales; a broad fuscous transverse band, anterior edge straight from midcosta to mid-dorsum, posterior edge suffused from three-fourths costa to tornus, on costa this band is dark fuscous, elsewhere paler; a dark fuscous spot on costa before apex; stigmata dark fuscous, first discal at one-third, plical beneath it, second discal before two-thirds, a dot between, and in a line with, discals; cilia whitish-grey. Hindwings and cilia pale grey.

Queensland: Mt. Tambourine in November; one specimen.

685. *EULECHRIA RHABDORA*, n. sp. (*ῥαβδος*, streaked.)

♂. 15 mm. Head white with a grey spot on crown. Palpi with second joint reaching base of antennae, terminal joint four-fifths; whitish. Antennae whitish (broken off short); ciliations in male 1. Thorax white with a central fuscous streak. Abdomen pale ochreous; apices of segments and tuft whitish. Legs whitish. Forewings narrow, sub lanceolate, costa strongly arched, apex pointed, termen extremely oblique; white with numerous longitudinal fuscous streaks; three long streaks from base, broadly interrupted; shorter oblique streaks run into apical third of costa and into termen; a subdorsal streak near base; cilia grey, bases whitish. Hindwings and cilia whitish.

Queensland: Brisbane in March; one specimen.

686. *EULECHRIA POLYMITA*, n. sp. (*πολυμιτος*, with many threads.)

♂, ♀. 20-21 mm. Head whitish with a median fuscous line. Palpi with second joint reaching base of antennae, terminal joint 1; whitish, base of second joint, and subapical rings on second and terminal joints, fuscous. Antennae grey, becoming whitish towards base; ciliation in male 1½. Thorax whitish; tegulae and three longitudinal lines fuscous. Abdomen whitish; bases of segments, except first, pale ochreous. Legs whitish; anterior pair fuscous internally. Forewings narrow, suboval, costa straight to near apex, apex round-pointed, termen very oblique; whitish with numerous fine longitudinal fuscous streaks; a subcostal streak from base of costa to two-fifths; two slender streaks from base; a median streak from one-third, bent upwards to costa before apex, with another closely parallel above it; several shorter streaks in disc and toward dorsum; cilia whitish with some basal fuscous bars. Hindwings and cilia grey-whitish.

The narrow forewings and markings are probably adaptations for concealment, perhaps on *Casuarina*.

Victoria: Gisborne in December; two specimens received from Mr. Geo. Lyell, who has the type.

687. *EULECHRIA SPILOPHORA*, n. sp. (*σπιλοφορος*, spotted.)

♂. 14 mm. Head whitish. Palpi with second joint reaching base of antennae, terminal joint three-fifths; whitish, base and a subapical ring on second joint, and some irroration, fuscous. Antennae grey; cilliations in male 1. Thorax grey-whitish with an anterior fuscous spot. Abdomen pale grey; tuft ochreous-whitish. Forewings narrow, slightly dilated, costa gently arched, apex rounded, termen obliquely rounded; ochreous-whitish; markings and some scattered scales dark fuscous; costal spots at one-fourth, middle and before apex; first discal at two-fifths, plical before it, elongated into a streak towards base, second discal at three-fifths, rather large; a curved line from third costal spot to tornus; cilia ochreous-whitish, bases with fine fuscous bars. Hindwings and cilia grey-whitish.

North Queensland: Herberton in March; one specimen.

688. *EULECHRIA AMYDRODES*, n. sp. (*ἀμυδροδης*, dark.)

♂, ♀. 18-19 mm. Head and thorax dark fuscous. Palpi with second joint reaching base of antennae, terminal joint three-fourths; fuscous mixed with ochreous-whitish. Antennae fuscous; cilliations in male 1½. Abdomen grey with several transverse brown bars on dorsum; tuft ochreous-whitish. Legs fuscous with whitish-ochreous rings; posterior pair mostly whitish-ochreous. Forewings elongate, costa moderately arched, apex pointed, termen very oblique; fuscous; stigmata sometimes indicated—first discal at one-third, plical beyond, second discal at two-thirds, a dot above and between discals; cilia fuscous. Hindwings and cilia grey.

Queensland: National Park (2,500 feet in open forest) in November; nine specimens.

689. *EULECHRIA SCHOIDES*, n. sp. (*σχοειδης*, dark.)

♀. 16 mm. Head fuscous. Palpi with second joint just reaching base of antennae, terminal joint three-fourths; fuscous, inner surface whitish. Antennae and thorax dark fuscous. Abdomen grey. Legs fuscous; posterior pair grey. Forewings narrow, costa straight except near base and apex, apex rounded, termen obliquely rounded; 2 and 3 connate; uniformly dark fuscous; cilia dark fuscous. Hindwings and cilia pale grey.

Western Australia: Mundaring near Perth in June; one specimen received from Mr. J. Clark.

690. *EULECHRIA XIPHOLEUCA* Low., *Tr.N.S.W.Aust.*, 1901, 89 (Broken Hill. Birchip).

691. *EULECHRIA STENOPTILA* Turn., *ibid.*, 1917, 101 (Adavale, Q.).

692. *EULECHRIA EPIPERCNA* Turn., *ibid.*, 1917, 100 (Dimbula, Sea Lake).

693. *EULECHRIA BRACHYMITA*, n. sp. (*βραχυμιτος*, with short threads.)

♂. 24 mm. Head and thorax whitish-grey. Palpi with second joint reaching base of antennae, terminal joint three-fourths; whitish-grey. Antennae whitish-grey; cilliations in male slightly more than 1. Abdomen whitish-grey; tuft ochreous-whitish. Legs fuscous; posterior pair ochreous-whitish. Forewings very narrow, costa gently arched, apex pointed, termen very oblique; whitish sprinkled with grey; markings fuscous; a short very oblique streak from base of costa; first discal at one-fourth; plical beyond it, second discal at three-fifths, its lower edge produced in a fine streak towards plical, two short streaks above and between discals; a dot on three-fifths costa, from which proceeds a fine outwardly oblique line, sharply angled before apex, and continued to tornus; a terminal series of minute dots; cilia whitish. Hindwings grey-whitish; cilia whitish.

Queensland: Toowoomba in April; one specimen.

694. *EULECHRIA OMBROPHORA* Meyr., P.L.S.N.S.W., 1883, 322 (= *actias* Low., *ibid.*, 1899, 106) (Broken Hill, Quorn, Pinnaroo, Carnarvon, W.A.).

695. *EULECHRIA SCIOPHANES* Meyr., *ibid.*, 1883, 323 (Talwood, Broken Hill. Quorn).

696. *EULECHRIA ISCHNOPHANES*, n. sp. (*ισχροφανης*, narrow.)

♂. 18 mm. Head and thorax fuscous. Palpi with second joint reaching base of antennae, terminal joint three-fourths; fuscous. Antennae fuscous; ciliations in male 1½. Abdomen grey; bases of segments ferruginous. Legs fuscous; posterior pair whitish. Forewings elongate, narrow, costa moderately arched, apex pointed, termen very oblique; whitish, rather densely but unevenly sprinkled with fuscous, the centre of disc being clearer; markings fuscous; a large circular spot on base of dorsum; a broadly suffused costal streak from one-sixth to two-thirds; first discal at one-fourth, plical beneath it, second discal at three-fifths, elongate transversely, a dot between and above discals, another beneath second discal, connected by suffusion with tornus; a line from four-fifths costa inwards, then abruptly angled outwards, and again inwards to tornus; cilia whitish with some fuscous scales. Hindwings with 5 from middle; grey; cilia grey.

Not unlike *E. ombrophora*, but that has much shorter palpi, second joint reaching middle of face, terminal joint one-half.

Victoria: Sea Lake in March; one specimen received from Mr. D. Goudie.

697. *EULECHRIA PROSERODES* Low., *Tr.R.S.S.Aust.*, 1907, 116 (Broken Hill, Pinnaroo).

698. *EULECHRIA AMPHISEMA* Low., *ibid.*, 1907, 117 (Broken Hill).

699. *EULECHRIA MERACA*, n. sp. (*meracus*, unmixed.)

♀. 32 mm. Head and thorax ochreous-whitish. Palpi slender, second joint not exceeding middle of face, terminal joint three-fourths; ochreous-whitish. Antennae ochreous-whitish. Abdomen brownish; apices of segments and tuft ochreous-grey-whitish. Legs ochreous-whitish; anterior pair ochreous-grey-whitish. Forewings elongate, oval, costa straight to beyond middle, thence strongly arched, apex rounded, termen obliquely rounded; ochreous-whitish; cilia ochreous-whitish. Hindwings and cilia ochreous-grey-whitish.

Allied to *E. autophyla* Low., which has similar palpi, but the second joint is longer, being about three-fourths length of face, and the terminal joint is one-half.

Queensland: Warwick in March; one specimen.

(To be continued.)

*Note.*—A complete alphabetical list of the species of *Eulechria* will be printed at the end of the description of species.

# AUSTRALIAN HESPERIIDAE. VII.

## NOTES ON THE TYPES AND TYPE LOCALITIES.

By G. A. WATERHOUSE, D.Sc., B.E., F.R.E.S.

[Read 30th June, 1937.]

During 1936 I spent a considerable time at the British Museum of Natural History, South Kensington, London. There I was able to examine all the Australian types of HesperIIDae in that vast collection and check over the results with my friend, Brigadier W. H. Evans. As Evans had been working on this family for several years, all the recent acquisitions had been put in their proper places. Thus my task with regard to this family was made much easier.

Mr. N. D. Riley, the Keeper of Entomology, gave me every facility to study the specimens and literature, and his advice on questions of nomenclature was very valuable. Mr. A. G. Gabriel also was of great assistance to me.

Besides the types of species described by the Lepidopterists of the Museum, all the types of Australian HesperIIDae described by Hewitson, many of those described by Mabille (received through the Oberthür collection) and a number of Fruhstorfer's are at the British Museum.

I had access to the registers, which in the case of specimens received many years ago gave information not on the labels, and clues to localities and collector. These registers go back to 1844, and record the origin of each batch of specimens under a separate number. The individual specimens are not listed in the register, but they bear a printed label with the year and acquisition number. In addition there are still older registers from which Mr. Riley had abstracted all the Australian references for me. I doubt if any important specimen escaped my study.

As so many skippers had been described by Hewitson from Australia, I made a special study of the specimens that had been in his collection and compared his descriptions with what are considered to be his types. Hewitson bequeathed his collection to the British Museum with the proviso that it be kept intact for 21 years and that a catalogue of it be prepared. This was done, and the list, prepared by Kirby, 1879, has been of great help, as it contains the number of specimens in the collection and their localities. I was able to find nearly all the Australian specimens mentioned by Kirby, only one important specimen being missing. As Hewitson, in many cases, did not publish all the information on his scanty labels, I was able to find out many new facts. He also had more than one distinct species under the one name, and apparently had very little knowledge of geographical distribution.

It has been stated that Hewitson considered a large label a disfigurement to a specimen. His labels are always small, and his localities, when given, always abbreviated. Thus I never found Australia written in full, but as Austral., Austrl. or Austl. For Moreton Bay he had Moreton, Morton, Mort., Mort. B., Mort. Bay or Mor. Bay. There is sufficient evidence that Hewitson, although he



described Australian species from other collections from other localities, received the bulk of his own Australian material from Swan River (Perth) and Moreton Bay (Brisbane). As many of his Moreton Bay specimens have *Strang.* or *Str.* added, it is almost certain that these were from Frederick Strange, who collected extensively near Brisbane. It may also explain the few South Australian species described by Hewitson, as Strange lived there for some time before going to Brisbane.

Mr. A. G. Gabriel, who was at the British Museum when the Hewitson collection was being labelled, has explained to me the procedure. A special label was printed with Hewitson Coll. on one line and 79-69 on the line beneath. 79 is the year 1879, and 69 is the acquisition number for that year. Room for writing was left both above and below the printing. Above the printing, Mr. F. A. Heron wrote in ink the unabbreviated locality, if any, taken from the pin. This small label was then gummed on the back of the printed label. If no locality was on the pin, Heron wrote the probable locality in pencil. Below the printing Heron then wrote in ink the name of the species taken from below the series in the collection. A number was added to this, representing the position of the specimen in the series. Hewitson rarely indicated a type and did not attach names to the specimens in his own collection, although he did so to species described from other collections. These details are important in arriving at a locality for his types and also in some cases in determining his species. The locality of Port Denison (Bowen) is wrong for many of his species, as I found labelled Pt. Den., three species from Fiji, one from Aru and one found only in south-western Australia. In consultation with Mr. Riley, it has been decided to reject this locality of Port Denison, unless confirmed by other evidence.

It is unfortunate that so many specimens in the British Museum were purchased in the past from dealers, as their localities are usually inadequate and in many cases erroneous.

In England I examined the Australian skippers described by Mr. E. Meyrick and saw what was available at Tring, thanks to the kindness of Lord Rothschild and Dr. K. Jordan. I have also seen the types of Miskin at Brisbane and Adelaide and have been very carefully through the Lower collection at Adelaide. All but two of my own types are in the Australian Museum, Sydney. I have copies of all the paintings of the new Australian skippers described by Plötz. It is unfortunate that, when these paintings were made from the originals in London, the other eastern species were not copied at the same time. Many of the figures in Seitz *Macrolepidoptera*, Vol. ix, are said to be taken from the unpublished drawings of Plötz, and I am sure that many others are from the same source. The determinations by Plötz of the older species are often inaccurate, and this accounts for species figured in Seitz under wrong names.

Notes on life-histories are only given if the information is new. The following notes, the result of my work in London last year, should bring the Australian species of this family into as perfect a state as possible at the present time. I am not giving references beyond the year of publication, as I have already published full lists in papers in *THESE PROCEEDINGS* for 1932, p. 238, and the *Records of the South Australian Museum*, v, 1933, pp. 61-2.

The references in parentheses after the specific or subspecific name refer to the figures in "The Butterflies of Australia", by Waterhouse and Lyell, 1914 (cited W. and L., 1914), in which the figures run consecutively from 1 to 888, and to "What Butterfly is That?", by G. A. Waterhouse, 1932 (cited Waterh., 1932), in which the coloured plates are numbered in roman. By this means the recent changes in

nomenclature will be recognized. The references to Seitz are to Vol. ix. As far as possible I have commented on as many published figures as possible, especially when they are incorrectly determined.

When I state that the types are in the British Museum or an Australian Museum, it is to be understood that I have examined them. The meanings of the various types are as follows:

Orthotype: Type of genus designated in original description.

Haplotype: Type by single reference (only species included).

Logotype: Type of genus by subsequent designation.

Holotype: The specimen of the species or race on which the description was based.

When a type is stated to be at Sydney, it is in the Australian Museum; when at Adelaide, it is in the South Australian Museum; and when at Brisbane, it is in the Queensland Museum.

#### Subfamily EUSCHEMONINAE.

EUSCHEMON Doubleday, 1846.

Haplotype, *Hesperia rafflesia* W. S. Macleay, 1826.

*E. rafflesia rafflesia* W. S. Macleay, 1826 (Waterh., 1932, Pl. xxviii, 1♂).—The holotype has been lost and I have assigned (1932) Port Macquarie, N.S.W., as its place of capture. A white aberration is *albo-ornatus* Olliff, 1891, from the Richmond River, N.S.W. This specimen has also disappeared. In the British Museum are two specimens of this aberration, both of which have some yellow scales on the white spots on the upperside. These scales occupy different positions on right and left wings. The first name given to the northern race was unfortunately applied to a white form, *alba* Mabille, 1903, from Cooktown. Holotype male in the British Museum. I have named the ordinary green form *viridis* Waterh., 1932 (W. and L., 1914, 590♂, 591♂; Waterh., 1932, Pl. xxviii, 2♂). Holotype male at Sydney.

#### Subfamily CELAENORRHINAE.

This subfamily, with the exception of *E. rafflesia*, contains all the Australian species that rest with their wings flat. Some have vein 5 of the hindwing tubular.

#### CHAETOCNEME Felder, 1860.

Logotype, *Chaetocneme corvus* Feld., 1860 (= *Papilio helirius* Cram., 1775). Synonyms: *Casyapa* Kirby, 1871, proposed by Kirby as he considered *Chaetocneme* preoccupied by *Chaetocnema* Steph., 1831. *Phoenicops* Watson, 1893, orthotype *Netrocoryne beata* Hew., 1867, is valid but not required as it only differs from *Chaetocneme* in the absence of a costal fold on the forewing in the male. This character is of little value for generic separation.

*C. critomedia sphinterifera* Fruhst., 1910 (W. and L., 1914, 575♀; Waterh., 1932, Pl. xxviii, 6♂).—Holotype male from Cape York in the British Museum from the Fruhstorfer collection. It does not agree with my specimens from Cape York, but is nearer to them than any of the other races in the British Museum. The Australian race has only been taken on the Cape York Peninsula. Miskin's record of Brisbane is an error, as is the record of W. Australia in the British Museum from the Godman and Salvin collection (ex Coll. Herbert Druce).

*C. porphyropis* Meyr. and Lower, 1902 (W. and L., 1914, 578♂; Waterh., 1932, Pl. xxviii, 6♂).—Holotype male from Johnstone River, N. Qld., at Adelaide. This species has a very small costal fold in the male. It may possibly be an extreme race of *C. caristus* Hew., 1867, but sufficiently distinct to be considered a species.

One of the two specimens of the latter species in the Hewitson collection is incorrectly labelled Port Denison.

*C. beata* Hew., 1867 (W. and L., 1914, 576♂, 577♀; Waterh., 1932, Pl. xxviii, 3♂, 3A♀).—Holotype male in the British Museum labelled Austrl. Str., so it must have come from near Brisbane. It is No. 1 and not the specimen figured by Hewitson, Exot. Butt., 1874, which is No. 3. The figures in Seitz Pl. 163 are too highly coloured, especially the male.

*C. denitza* Hew., 1867 (W. and L., 1914, 573♀, 579♀; Waterh., 1932, Pl. xxviii, 4♂).—Holotype male from Brisbane in the British Museum. Port Darwin, given by Lower, is a very doubtful locality. The figures in Seitz Pl. 163 are good.

#### EXOMETOECA Meyrick, 1888.

Haplotype, *E. nycteris* Meyr., 1888. The only species in the genus.

*E. nycteris* Meyr., 1888 (W. and L., 1914, 589♂, 887♂, 888♂; Waterh., 1932, Pl. xxviii, 7♀).—Holotype male from Albany in Meyrick collection. The species is confined to south-western Australia, and when at rest sits with its wings flat.

#### NETROCORYNE Felder, 1867.

Haplotype, *N. repanda* Feld., 1867.

*N. repanda repanda* Feld., 1867 (W. and L., 1914, 723♂; Waterh., 1932, Pl. xxviii, 8♂).—Holotype male is at Tring, labelled Moreton Bay. *Goniloba vulpecula* Prittwitz, 1868, from New Holland is a synonym of this race, which is found in southern Queensland and New South Wales to Sydney. The holotype female of the northern race *expansa* Waterh., 1932, from Kuranda is at Sydney. This race is rare in collections.

#### TAGIADES Hubner, 1823.

Logotype, *Papilio jopetus* Stoll, 1781.

*T. jopetus janetta* Butl., 1870 (W. and L., 1914, 724♀; Waterh., 1932, Pl. xxviii, 9♂).—Evans considers the following eastern races of *jopetus* to be inseparable: *janetta*, holotype male in the British Museum, from Aru; *gamelia* Misk., 1889, holotype male from Cape York at Brisbane; *australiensis* Mab., 1891, from Cape York, holotype probably lost; *lousia* Swinhoe, 1907, holotype female from Rossel Is. in the British Museum. As far as the specimens in the British Museum showed, there is little difference between specimens from Cape York and the holotype of *janetta* from Aru.

*T. nestus curiosa* Swinhoe, 1905 (W. and L., 1914, 780♂).—Evans has pointed out to me that there are two very similar species in the Papuan area and, having examined the male genitalia of the single specimen from Darnley Is., I find that it belongs to *nestus* Feld., 1860, and not to *sem* Mabille, 1883.

#### Subfamily HETEROPTERINAE.

Only one genus of this subfamily is found in Australia and only one species.

#### NOTOCRYPTA de Niceville, 1889.

This genus replaces *Plestoneura* Feld., 1862 (preoccupied), with the same orthotype, *P. curvifascia* Feld., 1862.

*N. waigensis proserpina* Butl., 1883 (W. and L., 1914, 736♀; Waterh., 1932, Pl. xxviii, 16♀).—Evans considers that *proserpina* Butl., holotype male in the British Museum from Aru, *leucogaster* Staudinger, 1889, from Cooktown, and *ribbei* Fruhst., 1911, holotype male in the British Museum from Key, all belong to the same race of *N. waigensis* Plötz, 1882. Mr. Manski has bred our race, the larvae feeding on *Alpinia caerulea* (Wild Ginger). They are long, slender and pale

green in colour. The pupa is long and cylindrical and greenish in colour, the proboscis is more or less free and extends beyond the posterior end of the pupa.

#### Subfamily RHOPALOCAMPTINAE.

This name must be used as *Ismene* Swainson, 1820, is preoccupied.

#### HASORA Moore, 1881.

Orthotype, *Goniloba badra* Moore, 1865. *Parata* Moore, 1881, orthotype, *Papilio chromus* Cram., 1780 (= *Papilio alexis* Fab., 1775), with sex mark on forewing in male, is not considered sufficiently distinct.

*H. hurama hurama* Butl., 1870 (W. and L., 1914, 727♂, 728♂; Waterh., 1932, Pl. xxviii, 13♂).—Holotype male from Cape York in the British Museum and agrees with the description, except that Butler does not mention the sex mark. The locality Champion Bay (Geraldton, W. Aust.) is erroneous.

*H. alexis contempta* Plötz, 1884 (W. and L., 1914, 729♂, 730♀; Waterh., 1932, Pl. xxviii, 14♂, 14A♀).—The holotype is stated to have come from Cape York, and I have specimens from there agreeing with the coloured figure of Plötz. The holotype male of *lucescens* Lucas, 1900, from Cairns is at Adelaide and is a synonym.

*H. khoda haslia* Swinhoe, 1899 (W. and L., 1914, 725♂, 726♀; Waterh., 1932, Pl. xxviii, 12♀).—Holotype male in the British Museum from Brisbane and agrees with the description, except that Swinhoe does not mention the sex scales along the veins of the forewing in the male. Seitz does not mention *khoda* Mabille, 1876, and erroneously puts *haslia* as a race of *alexis* Fab., 1775.

*H. discolor mastusia* Fruhst., 1911 (W. and L., 1914, 721♂, 722♂; Waterh., 1932, Pl. xxviii, 11♂).—Holotype male in the British Museum labelled Queensland, although Fruhstorfer gives Cape York in his description. It is in poor condition and has a narrower band on the underside of the hindwing than in other specimens I have seen.

#### ALLORA Waterhouse and Lyell, 1914.

Orthotype, *Ismene doleschalli* Feld., 1860.

The type of the Australian race, *A. doleschalli simessa* Fruhst., 1911 (W. and L., 1914, 719♂, 720♂; Waterh., 1932, Pl. xxviii, 10♂), from North Australia could not be found in the Fruhstorfer collection in the British Museum. I nominate Cape York as the locality for this race.

#### BADAMIA Moore, 1881.

Orthotype, *Papilio exclamatoris* Fab., 1775 (W. and L., 1914, 733♂, 734♀, 735♂; Waterh., 1932, Pl. xxviii, 15♂, 15A♀) is common throughout the Oriental and Australian regions. The holotype is probably lost. It does not seem to have developed into races, and in Australia occurs as far south as Sydney. In the eastern Pacific another species, *B. atrox* Butl., 1877, occurs with *exclamatoris*.

#### Subfamily TRAPEZITINAE.

This family is confined to Australia, except for three species from the New Guinea area. On the hindwing the internal veinlet has a fork to the origin of vein 4. Plötz, 1884, placed all the species he described and listed under *Telestus* Bois., 1832 (preoccupied).

#### TRAPEZITES Hübner, 1823.

Haplotype, *T. symmimus* Hb., 1823. *Patlasingha* Watson, 1893, with orthotype *Hesperia phigalia* Hew., 1868, is not distinct enough to warrant separation. *Steropes* Bois., 1832 (logotype *Papilio iacchus* Fab., 1775) is preoccupied.

*Trapezites symmimus* Hb., 1823 (W. and L., 1914, 731♀, 732♂; Waterh., 1932, Pl. xxviii, 17♀).—Described from New Holland; the figures in the second hundred of the *Zutrage* are of a male and agree best with specimens from Sydney, which must be taken as the locality of the holotype, which is undoubtedly lost. In 1932 I described the southern race *soma* from Frankston, Vict., and the northern race *sombra* from Herberton, Qld. The holotype males of both are at Sydney. Miskin, 1891, in his catalogue, marked this species as unknown to him, but he had it in his collection under the name *iacchus* Fab. This species has only one brood.

*T. iacchus* Fab., 1775 (W. and L., 1914, 596♂, 597♀; Waterh., 1932, Pl. xxix, 2♂).—Holotype a female in the Banksian cabinet in the British Museum. The locality Cooktown must be assigned to this specimen. Donovan's figure of the holotype is faulty as it shows an extra spot on the underside of the hindwing. This species is quite distinct from *eliena* Hew.; their ranges overlap for more than 300 miles in Queensland and the male genitalia are different. Hewitson had one male of this species and three males and one female of his *eliena*, all from Brisbane, under the name *iacchus*, as he considered the two species the same.

*T. eliena eliena* Hew., 1868 (W. and L., 1914, 604♂, 605♀; Waterh., 1932, Pl. xxix, 1♂).—Holotype male in the British Museum from Brisbane. In his collection Hewitson had sunk *eliena* to *iacchus*. Plötz, 1884, erroneously described *carcilius* from India. His unpublished figure 798 shows this to be a male *eliena*, as the orange band of the hindwing is divided by the veins. Plötz, 1884, sinks *eliena* Hew. to *iacchus* Fab. and incorrectly places the figure of *eliena* given by H-Sch., 1869, as a synonym of *donnysa* Hew. Meyrick and Lower, 1902, described this species under *iacchus*, with *eliena* as a synonym. Lower, 1911, corrected this mistake and gave a description of both. Figure 167h in Seitz is poor, especially the underside. There is no authentic record of this species from Tasmania. The second race of this species is *monocycla* Lower, 1911, from Mt. Gambier, S. Aust., holotype female at Adelaide. Most specimens have more than the central white spot on the underside of the hindwing. The best character to distinguish *monocycla* is the yellow colour of the hindwing on the underside. It is confined to South Australia and western Victoria. The species has two broods. Anderson and Spry, 1894, figure the race *monocycla* as *iacchus*.

*T. iacchoides* Waterh., 1903 (W. and L., 1914, 598♂, 599♂, 738♀; Waterh., 1932, Pl. xxix, 3♂).—Holotype male from Katoomba, N.S.W., at Sydney. This distinct species has one brood in the early spring. Probably other races occur, but, except near Sydney and the Blue Mts., the material is insufficient. *T. maheta* ab. *obruta* Seitz, 1927, is probably this species.

*T. maheta maheta* Hew., 1877.—Holotype male from Queensland in the British Museum. It agrees best with specimens from Brisbane which is nominated the type locality. Both the coloured and uncoloured figures of Herrich-Schaeffer, 1869, of *phigalia* represent the female of this species and fig. 167g in Seitz of *phigalia* is also a female. As his coloured drawing 796 shows, *praxedes* Plötz, 1884, from Sydney, in Berlin Museum, is the southern race (W. and L., 1914, 606♂, 607♂, 614♀; Waterh., 1932, Pl. xxix, 4♂, 4A♀). The species has two broods.

*T. phigalioides* Waterh., 1903 (W. and L., 1914, 615♀, 624♂, 625♂; Waterh., 1932, Pl. xxix, 5♂).—Holotype male from Victoria at Sydney. Figured as *phigalia* by Anderson and Spry, 1894. One brood in the early spring, sometimes found flying with *iacchoides*.

*T. phigalia phigalia* Hew., 1868 (W. and L., 1914, 612♂, 613♀; Waterh., 1932, Pl. xxix, 6♂).—This species was described from Australia and, although I have

an excellent coloured drawing of the female from the Hewitson collection, which is considered the holotype, I have found a difficulty in assigning the type locality. Kirby lists two specimens in the Hewitson collection, but only the female No. 2 could be found. A specimen of *T. petalia* Hew. labelled *Hesperilla phigalia* No. 1 was found, so some misplacement between these two species must have taken place, since both the specimens of *petalia* listed by Kirby were found. The female considered the holotype female does not quite agree with the description. I have selected near Adelaide as the type locality, as Hewitson determined a specimen for H. R. Cox, 1873, from there as *phigalia*. Comparing the expanses given by Hewitson on the same page, we find for *eliena*  $1\frac{1}{2}$  in., for *petalia*  $1\frac{1}{\infty}$  in., and for *phigalia*  $1\frac{1}{\infty}$  in. I should think that Hewitson was describing a male. If Victorian specimens are found to be distinct, the names *phlaea* Plötz, 1884, and *phillyra* Miskin, 1889, are available. The holotype male of the latter is at Adelaide. The race from southern Queensland with pinkish underside I have named *phila*, 1937. Holotype male at Sydney.

*T. sciron* Waterh. and Lyell, 1914 (W. and L., 1914, 746♂, 747♀; Waterh., 1932, Pl. xxix, 7♂).—Holotype male from Stirling Ranges, W. Aust., at Sydney. It is the only species of the genus in Western Australia.

*T. luteus luteus* Tepper, 1882 (W. and L., 1914, 660♂, 748♂; Waterh., 1932, Pl. xxix, 8♂).—Holotype male in poor condition from Ardrossan, S.A., at Adelaide. It must be rare in South Australia, as I do not know of more than seven specimens. Until more material is available from South Australia, I am keeping the specimens from Victoria (2), N. S. Wales and S. Qld. under the typical race. In Tasmania the race *glaucus* (W. and L., 1914, 661♂, 739♀; Waterh., 1932, Pl. xxix, 9♂) occurs. Holotype male at Sydney. This is listed by Plötz, 1884, as *petalia* and figured by Seitz Pl. 167 as *petalia*.

*T. petalia* Hew., 1868 (W. and L., 1914, 657♂, 658♀, 659♂; Waterh., 1932, Pl. xxix, 10♂).—Holotype male in the British Museum from Brisbane. I found the two specimens listed by Kirby that were in the Hewitson collection. In Meyrick's collection is a male with a Gayndah label. This must be the holotype of his *megalopsis*, 1888, which he considered a female. It is a synonym of this species. Although this species has a wide range in eastern Australia, it does not seem to have developed races. It has two broods. The figure in Seitz Pl. 167 is *T. luteus glaucus*.

*T. heteromacula* Meyr. and Lower, 1902 (W. and L., 1914, 622♀, 623♂; Waterh., 1932, Pl. xxix, 11♀).—Holotype male from Cooktown in the Macleay Museum, Sydney. A rare species. The name is also spelt *heliomacula* in the table of species.

#### ANISYNTOIDES Waterhouse, 1932.

Orthotype, *Cycloptides argenteo-ornatus* Hew., 1868. It is the only species in the genus.

*A. argenteo-ornatus argenteo-ornatus* Hew., 1868 (W. and L., 1914, 709♂, 710♀; Waterh., 1932, Pl. xxix, 14♂).—Holotype female in the British Museum from Swan River (Perth). This is the race on the mainland. The figure in Seitz Pl. 167 of the underside is not good. The race from the islands, typically from Monte Bello Is., is *insula* Waterh., 1932. Holotype male at Sydney.

#### PASMA Waterhouse, 1932.

Orthotype, *Hesperilla tasmanicus* Misk., 1889. Two rather dissimilar species are in this genus.

*P. tasmanicus* Misk., 1889 (W. and L., 1914, 750♂, 751♀; Waterh., 1932, Pl. xxix, 13♀).—Holotype male from Tasmania at Brisbane, not a female as stated by Miskin. Holotype male, *Telesio comma* Kirby, 1893, from Victoria in the British Museum, not a female as stated by Kirby. The lowest spot of the subapicals of the forewing is produced like a comma, this is unusual. I cannot see any subspecific differences in specimens from Tasmania, Victoria and N. S. Wales.

*P. polysema* Lower, 1908 (W. and L., 1914, 745♀, 754♂; Waterh., 1932, Pl. xxix, 12♂).—Holotype female from Petford, Qld., at Sydney. A rare northern species.

#### ANISYNTA Lower, 1911.

Orthotype, *Cyclopides cynone* Hew., 1874. The species of this genus have squarer wings and are not so robust as those of *Trapezites*.

*A. cynone cynone* Hew., 1874.—Holotype male in the British Museum with no more definite locality than Australia. It is the only specimen in the Hewitson collection listed by Kirby. The description agrees fairly well with the type, but there are only six spots, not seven, on forewing upperside, one in the cell and 2 and 3 and three subapicals, also the central spot on the upperside of the hindwing is a blemish. As it does not quite agree with specimens taken near Adelaide and may possibly have been caught by Strange during his travels in South Australia, it is perhaps best to keep it as a race from an unknown locality, probably on the Murray River. The figure in Seitz Pl. 171d of the underside bears little resemblance to the species. The race near Adelaide is *gracilis* Tepper, 1882 (W. and L., 1914, 761♂, 762♀, 763♂; Waterh., 1932, Pl. xxix, 15♂). Holotype male at Adelaide from Salisbury, Adelaide Plains. Both Tepper's specimens are males. The holotype male of the Victorian race *grisea* Waterh., 1932, Pl. xxix, 16♂, is at Sydney from Kerang. This locality is in northern Victoria not far from the Murray River.

*A. sphenosema* Meyr. and Lower, 1902 (W. and L., 1914, 643♀, 644♂, 645♂, 646♂; Waterh., 1932, Pl. xxix, 17♂, 17A♀).—Holotype male (described as a female) at Adelaide from Perth. Hewitson had a specimen in his collection with the impossible locality Port Denison, Qld. Lower, 1911, sunk *paraphaes* Meyr. and Lower, 1902, from Perth, under *sphenosema*, but the holotype could not be found at Adelaide. There are specimens of *sphenosema* labelled *paraphaes* by Lower in the Australian Museum. There is a female of *sphenosema* in the British Museum from the Hewitson collection incorrectly labelled Port Denison.

*A. tillyardi* Waterh. and Lyell, 1912 (W. and L., 1914, 767♂, 768♀, 769♂; Waterh., 1932, Pl. xxix, 18♂).—Holotype male from Ebor, N. S. Wales, at Sydney. This species is only found above 2,000 ft.

*A. monticolae* Olliff, 1890 (W. and L., 1914, 758♂, 759♀, 760♂; Waterh., 1932, Pl. xxx, 21♂).—Holotype male from Mt. Kosciusko, N. S. Wales, at Sydney. Only occurs above 3,000 ft.

*A. dominula dominula* Plötz, 1884.—Plötz described his species from Tasmania and his fig. 791 represents a male of the larger Tasmanian race, probably from near Launceston. Seitz figures this on Pls. 168 and 171, the latter figures being the better. The small mountain race is *pria* Waterh., 1932, from Cradle Mt., Tas., holotype male at Sydney. The race from Australia is *drachmophora* Meyr., 1885 (W. and L., 1914, 764♂, 765♀, 766♂; Waterh., 1932, Pl. xxx, 20♂), from Mt. Kosciusko. I saw the holotype male in Meyrick's collection.

## SIGNETA Waterhouse and Lyell, 1914.

Orthotype, *Telesto flammeata* Butl., 1882. The males have an ovoid sex mark on the upperside of the forewing.

*S. flammeata* Butl., 1882 (W. and L., 1914, 652♂, 653♀, 654♀; Waterh., 1932, Pl. xxix, 20♂, 20A♀).—Holotype female from Melbourne in the British Museum with the holotype male of *T. eclipsis* Butl., 1882, the other sex. *Hesperilla atromacula* Misk., 1889, is a synonym. I have seen the holotype male from Victoria at Brisbane. This species is only found in the early autumn.

*S. tymbophora* Meyr. and Lower, 1902 (W. and L., 1914, 662♂, 663♀, 664♂; Waterh., 1932, Pl. xxix, 19♂).—Holotype male from Mt. Kembla, N. S. Wales, at Adelaide. Also an autumn species. It has recently been taken at Barrington Tops.

## DISPAR Waterhouse and Lyell, 1914.

Orthotype, *Telesto compacta* Butl., 1882. This species has the uncus in the male sharply pointed, unlike any other Trapezitinae. The sexes are widely different, so much so that Watson, 1893, considered they belonged to different genera.

*D. compacta* Butl., 1882 (W. and L., 1914, 705♂, 706♀, 707♂, 708♀; Waterh., 1932, Pl. xxx, 22♂, 22A♀).—Holotype male from Melbourne in the British Museum. Holotype female, *Telesto scepticalis* Rosenstock, 1885, from Melbourne in the British Museum is this species. Holotype male, *Hesperilla melissa* Mab., 1891, labelled Sydney, is in the British Museum and is a synonym. A coloured drawing of *Hesperilla atrax* Mab., 1891, shows that it is a female of this species. It is described from Australia. Lower, 1911, states the holotype is in the Berlin Museum (Coll. Staudinger).

## TOXIDIA Mabilite, 1891.

Haplotype, *Toxidia thyrrhus* Mab., 1891. The following genera are included here: *Telesto* Boisdu., 1832, haplotype *Hesperia peron* Latr., 1824, preoccupied in 1812. *Oxytoria* Mab., 1904, logotype *Telesto doubledayi* Feld., 1862. *Timoconia* Strand, 1909, orthotype *T. thielei* Strand, 1909 (= *Hesperia peron* Latr.). *Oxytoria* and *Timoconia* are available if their genotypes are found to be generically different from *thyrrhus*. *T. thielei* was described from a specimen supposed to come from Africa.

*T. peron* Latr., 1824 (W. and L., 1914, 620♂, 621♂, 742♀; Waterh., 1932, Pl. xxx, 13♂).—Holotype male in the Paris Museum from Australia. Considering the date, Sydney is nominated the type locality. The holotype of *Telesto kochi* Feld., 1862, from Sydney could not be found at Tring. The figures in Seitz are stated to be from cotypes in Koch's collection. Holotype male of *Hesperilla doctea* Hew., 1868, from Moreton Bay in the British Museum. In Exot. Butt., v, 1874, Hewitson figured the female of this species as the female of *M. halysia*. Holotype female *Telesto arsenia* Plötz, 1884, in the Berlin Museum and his figure 805 show it to be the female of this species. Evans has seen the holotype male of *T. thielei* Strand, 1909, in the Berlin Museum, described in error from Africa. It is this species.

*T. crypsigramma* Meyr. and Lower, 1902 (W. and L., 1914, 639♂, 640♂; Waterh., 1932, Pl. xxx, 15♂).—Holotype male from Herberton, Qld., at Adelaide. When its larva and pupa are known it may be found to belong to *Hesperilla*.

*T. doubledayi* Feld., 1862 (W. and L., 1914, 608♂, 609♂; Waterh., 1932, Pl. xxx, 10♂).—The holotype male of this and that of the female *T. leachi* Feld., 1862,



both from Sydney, could not be found at Tring. *Carystus vallio* Mab., 1891, represented by forewings in the British Museum, and *vallio* in Mabilles's writing is a female of this species. Figure 803 of *extranea* Plötz, 1884, seems to represent *leucostigma* rather than *doubledayi*. Herrich-Schaeffer, 1869, figures this as *H. dirphia* Hew. In Seitz Pl. 167 the figures of the sexes are reversed.

*T. leucostigma leucostigma* Meyr. and Lower, 1902 (W. and L., 1914, 616♂, 617♂; Waterh., 1932, Pl. xxx, 11♂).—Holotype male, from near Sydney, at Adelaide. The northern race is *parasema* Lower, 1908 (W. and L., 1914, 637♂, 638♀; Waterh., 1932, Pl. xxx, 12♀). Holotype male from Kuranda, Qld., at Adelaide.

*T. parvulus* Plötz, 1884 (W. and L., 626♂, 627♂; Waterh., 1932, Pl. xxx, 8♂).—Fig. 790 of Plötz shows the holotype is a male from New Holland. I nominate Rockhampton as the type locality. *Hesperilla humilis* Misk., 1889, is the same species, holotype male from Brisbane at Brisbane. *Hesperilla ismene* must date from Anderson and Spry, 1894. The name *ismene* is said to have been given by Newman, but, although used several times previously, no description appeared until 1894.

*T. thyrrhus* Mab., 1891 (W. and L., 1914, 618♂, 619♂; Waterh., 1932, Pl. xxx, 9♂).—Holotype female from Cooktown in the Berlin Museum. A coloured drawing of it shows it to be a female, and not a male as stated by Mabilles. *T. bathrophora* Meyr. and Lower, 1902, holotype male from Mackay at Adelaide is the same species. Miskin in his collection had this species under *halyzia*, a species not in his collection.

*T. melanta* Waterh., 1903 (W. and L., 1914, 667♂, 668♀, 669♂; Waterh., 1932, Pl. xxx, 14♂).—Holotype male from Cairns at Sydney.

#### NEOHESPERILLA Waterhouse and Lyell, 1914.

Orthotype, *Hesperilla croceus* Misk., 1889. The genus is found only in Queensland and North Australia and consists of four closely allied species.

*N. croceus* Misk., 1889 (W. and L., 1914, 647♂, 655♀, 753♂; Waterh., 1932, Pl. xxx, 5♂).—Holotype male from Cooktown at Brisbane. Miskin described the female of *xanthomera* as the female of this species. *Hesperilla satulla* Mab., 1891, is a female from Cooktown in the Berlin Museum.

*N. ziphiphora* Lower, 1911 (W. and L., 1914, 656♂; Waterh., 1932, Pl. xxx, 6♂).—Holotype male from Port Darwin at Adelaide.

*N. senta* Misk., 1891 (W. and L., 1914, 665♀, 666♀, 752♂; Waterh., 1932, Pl. xxx, 7♂).—Holotype female from Herberton, Qld., at Brisbane.

*N. xanthomera* Meyr. and Lower, 1902 (W. and L., 1914, 673♂, 674♂, 675♀; Waterh., 1932, Pl. xxx, 3♂, 3A♀).—Holotype male from Townsville, Qld., at Adelaide. For an important note on this type see *Records South Australian Museum*, v, p. 58, 1933.

#### MESODINA Meyrick, 1901.

Orthotype, *Hesperilla halyzia* Hew., 1868. Lower, 1911, erroneously gives the orthotype as *M. aeluropis* Meyr.

*M. halyzia halyzia* Hew., 1868 (W. and L., 1914, 688♂, 689♂; Waterh., 1932, Pl. xxx, 1♂).—Holotype male in the British Museum labelled Port Denison. As there are no other records from north of Brisbane and most of Hewitson's records of Port Denison are wrong, I nominate Brisbane as the type locality. In Exot. Butt., v, 1874, Hewitson figured the female *peron* as the female of this species and marked them so in his collection. Miskin applied this name to *thyrrhus*. The figures in Seitz Pl. 171 are poor, especially that of the underside.

The race from Western Australia is *cyanophracta* Lower, 1911 (W. and L., 1914, 774♂, 775♀). Holotype male from Perth at Adelaide.

*M. aeluropis* Meyr., 1901 (W. and L., 1914, 698♂, 699♂; Waterh., 1932, Pl. xxx. 2♂).—I have seen the holotype male from Katoomba, N. S. Wales, in Meyrick's collection.

#### CROITANA Waterhouse, 1932.

Orthotype, *Cyclopides croites* Hew., 1874.

*C. croites croites* Hew., 1874 (W. and L., 1914, 757♂; Waterh., 1932, Pl. xxx. 3♂).—Holotype female in the British Museum labelled Australia and no doubt came from near Perth. The more interior race is *pindar* Waterh., 1932 (W. and L. 1914, 755♂, 756♀). Holotype male from Pindar, W.A., at Sydney. A very worn male from Hermannsburg, Central Australia, probably belongs here.

#### OREISPLANUS Waterhouse and Lyell, 1914.

Orthotype, *Hesperilla munionga* Olliff, 1890.

*O. munionga* Olliff, 1890 (W. and L., 1914, 670♀; Waterh., 1932, Pl. xxxii, 17♂).—Holotype male from Mt. Kosciusko, N. S. Wales, at Sydney.

*O. perornatus* Kirby, 1893 (W. and L., 1914, 594♂, 595♂; Waterh., 1932, Pl. xxxii, 16♂).—Holotype female from Victoria in the British Museum. The figures of *ornata* uppersides in Seitz Pl. 167f are this species.

#### HESPERILLA Hewitson, 1868.

Orthotype, *Hesperia ornata* Leach, 1814. The differences in the larvae and pupae are the chief points to separate this genus from *Toxidia*, the larvae and pupae of which are more like those of *Trapezites*. On this account *malindeva* was placed here, and now, for the same reason, *sezugtlata* comes into this genus. Probably *cryptogramma* will be found to belong here.

*H. ornata ornata* Leach, 1814 (W. and L., 1914, 602♂, 603♂; Waterh., 1932, Pl. xxxii, 13♂).—Holotype could not be found in the British Museum. Sydney must be the locality of the type. The figures in Seitz Pl. 167f of the uppersides of *ornata* are *perornatus* and of the underside *picta*. The northern race is *monotherm* Lower, 1907 (W. and L., 1914, 635♀, 636♀; Waterh., 1932, Pl. xxxii, 14♀), holotype female from Kuranda, Qld., at Adelaide.

*H. picta* Leach, 1814 (W. and L., 1914, 610♂, 611♂; Waterh., 1932, Pl. xxxii, 10♂).—Holotype could not be found at the British Museum. Sydney must be the type locality. The figure of the underside of *ornata* is *picta* and the figures of *picta* are very poor on Seitz Pl. 167.

*H. crypsargyra crypsargyra* Meyr., 1888 (W. and L., 1914, 600♂, 601♂; Waterh., 1932, Pl. xxxii, 11♂).—I have seen the holotype male from the Blue Mts., N. S. Wales, in Meyrick's collection. The northern race in New South Wales is *hopsani* Waterh., 1927 (Waterh., 1932, Pl. xxxii, 12♀). Holotype male from Barrington Tops at Sydney.

*H. mastersi* Waterh., 1900 (W. and L., 650♂, 651♂; Waterh., 1932, Pl. xxxii, 9♂).—Holotype male from Clifton, N. S. Wales, at Sydney. This rare species has recently been taken at Port Macquarie, N. S. Wales.

*H. idothea idothea* Misk., 1889 (W. and L., 1914, 716♂, 717♀, 718♂; Waterh., 1932, Pl. xxxii, 8♂, 8A♀).—Holotype female from Victoria at Adelaide. Holotype male and allotype female of *Trapezites dispar* Kirby, 1893, from Victoria are in the British Museum and are the same species. The South Australian race is *clara* Waterh., 1932, holotype male from Mt. Lofty at Sydney.

*H. andersoni* Kirby, 1893 (W. and L., 1914, 770♂, 771♀, 772♂; Waterh., 1932, Pl. xxxii, 7♂).—Holotype male from Victoria in the British Museum.

*H. chaostola chaostola* Meyr., 1888.—I have seen the holotype male from Blackheath, N. S. Wales, which was the only specimen in Meyrick's collection. The Victorian race is *chaos* Waterh., 1933 (W. and L., 1914, 690♀, 691♂, 700♂; Waterh., 1932, Pl. xxxii, 1♂). Holotype male at Sydney.

*H. chrysotricha chrysotricha* Meyr. and Lower, 1902 (W. and L., 1914, 631♂, 777♂; Waterh., 1932, Pl. xxxii, 5♂, 5A♀).—Holotype male from Albany, W. Aust., at Adelaide. The Victorian race is *cyclopsila* Meyr. and Lower, 1902. Holotype male also at Adelaide. In *Records South Australian Museum*, v, p. 56, 1933, I have discussed this race. *H. leucopsila* Waterh., 1927, is a synonym, holotype male in National Museum, Melbourne. The Tasmanian race is *plebeia* Waterh., 1927 (W. and L., 1914, 632♂; Waterh., 1932, Pl. xxxii, 6♂). Holotype male at Sydney.

*Hesperilla donnysa* Hew., 1868.—I find it difficult to assign a locality for the holotype male of this species in the British Museum from the Hewitson collection. Hewitson described both male and female and gave as locality Australia (Moreton Bay). He says: "Female without the small yellow spot of the anterior wing and the central orange of the posterior wing." These two characters are, however, always found in females of all races of *donnysa*. Therefore, his female was not this species. This is borne out by the fact that Hewitson, when figuring the upperside of the male in *Exot. Butt.*, v, 1874, omits any reference to the female. Also in Kirby's list only one specimen is mentioned with the locality Australia. The holotype bears the label "Austl." in Hewitson's writing. It appears to me that Hewitson transferred the locality Moreton Bay from his 1868 description to his 1874 description without looking at the label, Moreton Bay being the locality of his female. The species is very rare in the Moreton Bay district, as I have only seen one specimen, and that a male, from Stradbroke Is. The excellent coloured drawing I brought from London certainly agrees best with specimens from eastern Australia, but there is evidence that Hewitson received his eastern material only from near Brisbane. Perhaps for the present Moreton Bay may be retained as the locality of the holotype.

*H. donnysa donnysa* Hew., 1868 (W. and L., 1914, 633♂, 634♀; Waterh., 1932, Pl. xxxii, 2♂).—Holotype male in the British Museum from Australia. I have many specimens from N. S. Wales and eastern Victoria. The race from Altona Bay, Vict., is *avesces* Waterh., 1927 (Waterh., 1932, Pl. xxxii, 3♂); from Tasmania is *aurantia* Waterh., 1927; from South Australia *diluta* Waterh., 1932; from S.W. Australia *albina* Waterh., 1932 (W. and L., 1914, 776♀; Waterh., 1932, Pl. xxxii, 4♂); from Geraldton, W. Aust., *galena* Waterh., 1927. The holotype males of these races are at Sydney. In the Banksian Cabinet is a female *donnysa* labelled Friendly Is. Nelson; this agrees with specimens I have taken near Botany Bay. There are also in the British Museum two males from the New Hebrides, H.M.S. Dart, acquired in 1892; one of these has a small label Mt. Wellgn. Feb. 1890, so they must have come from Tasmania with other species under the registration 92-144.

*H. malindava* Lower, 1911 (W. and L., 1914, 740♂, 741♀, 749♂; Waterh., 1932, Pl. xxxii, 15♂, 15A♀).—Holotype male from Herberton, Qld., at Adelaide.

*H. serguttata serguttata* H.-Sch., 1869 (W. and L., 1914, 641♂, 642♀; Waterh., 1932, Pl. xxx, 16♂).—Holotype female from Rockhampton, probably lost. The race from Banks Is. is *sela* Waterh., 1932, holotype male at Sydney. The material available of this species is still insufficient to determine the races and their range.

Dr. T. Guthrie and Mr. M. J. Manski have bred this species at Cairns, Qld., feeding on *Cyperus pinnatus*. The larvae are like those of the other *Hesperilla* and the pupa has a headpiece somewhat like that of *matildeva*. It must therefore be removed from *Toxidia* to *Hesperilla*.

MOTASINGHA Watson, 1893.

Orthotype, *Hesperilla dirphia* Hew., 1868. The early stages of the two species in this genus are more closely allied to *Hesperilla* than to *Toxidia*.

*M. dirphia dirphia* Hew., 1868.—Holotype female from Swan River in the British Museum, as well as the other female indicated by Hewitson in his description. In Exot. Butt., v, 1874, the male is figured and is also in the British Museum. The race from South Australia is *trimaculata* Tepper, 1882, holotype male at Adelaide, together with the holotype female *quadrinaculata* Tepper, 1882, the female of this race, which Tepper later (1890) called *petalia* Hew. Two races occur in New South Wales, the holotype males being at Sydney. These are *dilata* Waterh., 1932 (W. and L., 1914, 628♂, 629♀, 630♂; Waterh., 1932, Pl. xxx, 19♂, 19A♀), from Sydney and *dea* Waterh., 1933, from the Blue Mts.

*M. atralba atralba* Tepper, 1882.—Holotype female consisting of two forewings at Adelaide. Tepper's figures of this and the other species described by him are very inaccurate. The typical race from South Australia is *atralba* (W. and L., 1914, 649♀; Waterh., 1932, Pl. xxx, 17♂). The male has a narrow inconspicuous stigma unlike the broad stigma of the Western Australian races. These are *nila* Waterh., 1932, holotype male from Dirk Hartog Is. at Sydney; *dactyliota* Meyr., 1888, holotype male from Geraldton in Meyrick's collection; the large race *anaces* Waterh., 1937 (W. and L., 1914, 648♀, 773♂; Waterh., 1932, Pl. xxx, 18♂), from Hamel; and *anapus* Waterh., 1937, from Stirling Ranges. The holotype males of *anaces* and *anapus* are at Sydney.

#### Subfamily HESPERIINAE.

As the type of the genus *Hesperia* Fab. has been determined to be *Papilio comma* Linn., 1758, this subfamily name must be used in place of Pamphilinae. The Australian species have mostly come here by way of New Guinea, where many more species are found. To a very great extent I have to rely on Brigadier Evans for information on the species that range beyond Australia. I begin with those species with a pronounced headpiece in the pupa, in this way resembling the *Hesperilla*.

PELOPIDAS Walker, 1870.

Haplotype, *Pelopidas midas* Walker, 1870 (= *Celaenorrhinus thrax* Hb.). Unfortunately this name has to replace *Chapra* Moore, 1881, with orthotype *Hesperia mathias* Fab., 1798. Evans has pointed out that *mathias* Fab. does not occur in Australia, but there are two distinct species somewhat similar, but larger.

*P. agna* Moore, 1865 (Waterh., 1932, Pl. xxxiv, 10♂).—This is the large greenish species figured as *Baoris mathias* Fab. The tips of the antennae are reddish and the lower spot in cell of the forewing, if present, is nearer the base than in *lyelli*.

*P. lyelli* Rothschild, 1915 (W. and L., 1914, 711♂, 712♀, 713♂; Waterh., 1932, Pl. xxxiv, 10A♀).—Holotype from Vulcan Is. This has a whiter sex mark, the tips of the antennae are black. I have not yet had time to go through the large number of specimens at Sydney to give the distribution of this and the previous species.

*P. impar* Mab., 1883.—This species is from New Caledonia (described from Oceania). Two races are found in Australia. That from Port Darwin is *lavinia* Waterh., 1932 (W. and L., 1914, 743♂, 744♀; Waterh., 1932, Pl. xxxiv, 11♂). Holotype male at Sydney. Specimens from Banks Is. are *contiguialis* Rothschild, 1915.

*P. cinnara* Wallace, 1866 (W. and L., 1914, 778♂, 779♂; Waterh., 1932, Pl. xxxiv, 13♂).—Evans considers this species has not developed races. It is figured (778–9) as *Parnara colaca* Moore.

*P. bevani* Moore, 1878 (Waterh., 1932, Pl. xxxiv, 14♂).—The three specimens from Port Darwin are considered by Evans to have been introduced.

#### PARNARA Moore, 1881.

Orthotype, *Eudamus guttatus* Brem., 1853. *Buorynnis* Waterh., 1932, with orthotype *Pamphila amalia* Semper, 1878, is a synonym.

*P. bada sida* Waterh., 1934 (W. and L., 1914, 714♂, 715♀; Waterh., 1932, Pl. xxxiv, 12♂).—Holotype male from Kuranda, Qld., at Sydney.

*P. amalia* Semper, 1878 (W. and L., 1914, 686♂, 687♀; Waterh., 1932, Pl. xxxiv, 9♂).—Holotype male is said to be in the Hamburg Museum. I have seen a drawing of it sent to Lower; it is now without a head. The holotype male (not a female as stated by Miskin) of *fulgidus* Misk., 1889, from Brisbane is at Brisbane, and is this species. I once considered *Pamphila sigida* Mab., 1891, as this species. The type is in the British Museum labelled Sydney. Evans finds it is *Atrytonopsis verna* Edwards, 1862, from North America.

#### TARACTROCERA Butler, 1869.

Orthotype, *Hesperia macvius* Fab., 1793. *Bibla* Mab., 1904, haplotype *Hesperia papyria* Boisdu., 1832, is available for species with a stigma in the male.

*T. papyria papyria* Boisdu., 1832 (W. and L., 1914, 580♂, 581♀; Waterh., 1932, Pl. xxxii, 18♂, 18A♀).—Holotype male probably in the Paris Museum and the locality Sydney must be used for it. Holotype male of *celacno* Cox, 1873, from Nairne, S. Aust., is in the British Museum; *fumosa* Guest, 1882, is also from S. Aust., holotype male at Adelaide, and *alix* Plötz, 1884, from New Holland. The Western Australian race is *agraulia* Hew., 1868 (W. and L., 1914, 585♂, 586♀; Waterh., 1932, Pl. xxxii, 19♂), holotype male from Swan River in the British Museum, together with another male from the same locality and a pair erroneously labelled Moreton Bay, all from the Hewitson collection. Miskin's species *minimus*, 1889, is a synonym of this race as, although he describes both races, his primary description applies to *agraulia*. His holotype is at Brisbane. Lower always considered that *agraulia* was the same as *flavovittata* Latr. So far this species has not been found beyond Australia.

*T. dolon dolon* Plötz, 1884 (W. and L., 1914, 876♂, 877♀; Waterh., 1932, Pl. xxxiii, 2♂, 2A♀).—I have never been satisfied that we have correctly determined this species. It was described by Plötz as an MS. name of Herrich-Schaeffer and Plötz's figure 769, of which I have a copy, seems to be a female. The holotype probably came from Rockhampton, Qld. The description and figure might apply to the female of *T. ina iola* Waterh., 1933, or a race of *walkeri*, indeed the former is a better fit than what is known in Australia as *dolon*. The underside of the hindwing with rings in 2, 3 and 6 and the centre belongs to no skipper I know of in Australia. Mr. Max Day has extended its range to Port Macquarie, N.S.W. The race from the Northern Territory is *diomedes* Waterh., 1933, holotype male at Sydney.

*T. ina ina* Waterh., 1932, Pl. xxxiii, 3♂.—Holotype male from Port Darwin at Adelaide. It is the specimen Lower described as the female *anisomorpha* Lower, 1911. When I described this species less than ten specimens were known. It is not rare on the east coast of Queensland, especially at Mackay. I have named these *iola* Waterh., 1933, holotype male from Hayman Is. at Sydney. Probably this is the true *dolon* Plötz.

*T. anisomorpha* Lower, 1911 (W. and L., 1914, 883♂, 884♀; Waterh., 1932, Pl. xxxiii, 4♂, 4A♀).—Holotype male from Port Darwin at Adelaide. A rare species with a wide range, but not yet caught commonly in any locality. Also found in Timor.

*T. illa illa* Waterh., 1932, Pl. xxxiii, 1♂.—A very rare species from the Northern Territory. Holotype male at Sydney. The race *beta* Evans, 1934, is found in Dutch New Guinea.

#### Ocybadistes Heron, 1894.

Orthotype, *Ocybadistes walkeri* Heron, 1894, from Damma Is., holotype male in the British Museum. Seitz omits *walkeri* from the genus and places it in *Telicota*. The species were formerly placed by me in *Padraona* Moore, 1881.

*O. flavovittata* Latr., 1824.—This name has a very unfortunate history, and at different times has been applied to almost every small brown and orange skipper in Australia. Unless a definite description is given by the earlier writers, it is impossible to know to which species they are referring. Semper, 1878, seems to have made the best of the earlier attempts as he lists both *flavovittata* and *sunias*. Miskin had but two specimens in his collection. Meyrick and Lower, 1902, used *flavovittata* for the western *agraulia*, and under *sunias* included three species. In my catalogue, 1903, I had at least four species under *sunias* and used *flavovittata* for *agraulia*. Lower, 1911, still placed *flavovittata* as a *Taractrocera*, but made *sunias*, *rectivitta*, *walkeri*, and *hypomeloma* distinct species. In 1914 it was pointed out that *flavovittata* could only have come from Sydney and was not a *Taractrocera*. To this Mr. N. D. Riley, 1926, agreed. In 1932 Brigadier Evans pointed out to me that amongst my long series there were two distinct species, one with a broad stigma in the male and one with a narrow stigma. This was the first time that the number of somewhat similar brown and orange species was definitely known. Acting on the report that a specimen with a Latreille label "*flavovittata*" then in Oberthür collection (ex Coll. Boisduval) was the species with a broad stigma, I described, in 1932, the species with the narrow stigma as *hespera*. The Latreille specimen is now in the British Museum, and is a female of the species with a narrow stigma in the male. It is undoubtedly one of the females Latreille had before him and probably the only one of these now in existence. It is strange that Latreille should have had only this species, as its female is rarer than that of the species with the broad stigma. It is to be hoped that confusion about this name is now finally settled. I agree to accept the Latreille specimen in the British Museum as the probable holotype female.

*O. flavovittata flavovittata* Latr., 1824 (W. and L., 1914, 866♀; Waterh., 1932, Pl. xxxiii, 11♂, 11A♀).—The name *hespera* Waterh., 1932, falls as a synonym, holotype male at Sydney. The race from North Queensland is *ceres* Waterh., 1933, and from Port Darwin is *vesta* Waterh., 1932 (W. and L., 1914, 858♂, 865♀). Holotype males of both at Sydney. This species has not yet been found beyond Australia.

*O. walkeri* Heron, 1894.—There are four races of this species from Australia; *olivina* Waterh., 1933, from Port Darwin; *sonia* Waterh., 1933, from Queensland;

*sothis* Waterh., 1933 (W. and L., 1914, 859♂; Waterh., 1932, Pl. xxxiii, 9♂, 9A♀), from Sydney, the holotype males of which are at Sydney. The holotype male of the South Australian race *hypochlora* Lower, 1911 (W. and L., 1914, 860♂, 867♀; Waterh., 1932, Pl. xxxiii, 10♂), is at Adelaide.

*O. hypomeloma hypomeloma* Lower, 1911 (W. and L., 1914, 584♂, 873♂, 874♀; Waterh., 1932, Pl. xxxiii, 8♂, 8A♀).—Holotype male from Sydney at Sydney, together with the holotype male of the race *vaga* Waterh., 1932, from Prince of Wales Is., Qld.

*O. ardea heterobathra* Lower, 1908 (W. and L., 1914, 872♂; Waterh., 1932, Pl. xxxiii, 7♂).—Holotype male from Kuranda, Qld., at Adelaide. Other races in New Guinea.

#### SUNIAS Evans, 1934.

Orthotype, *Pamphila lascivia* Rosenstock, 1885.

*S. lascivia lascivia* Rosenstock, 1885 (W. and L., 1914, 587♂, 588♂; Waterh., 1932, Pl. xxxiii, 14♂).—Holotype female in the British Museum from Victoria. The North Queensland race is *neocles* Mab., 1891 (Waterh., 1932, Pl. xxxiii, 15♂), from Cooktown. The holotype could not be found in the British Museum and is probably lost. The holotype male of *lasus* Waterh., 1937, from Bathurst Is. is at Sydney. Other races occur in Timor and New Guinea.

*S. sunias* Feld., 1860.—The identity of this small and widespread skipper has been a trouble for many years. Almost every small brown and orange eastern Australian species has had this name attached to it. In my early days I had no less than four different species under the name. Considerable advance was made in 1914 and again in 1932. There seems to be no doubt that our northern race is *rectivitta* Mab., 1878 (W. and L., 1914, 582♀, 583♂, 875♂, 882♂; Waterh., 1932, Pl. xxxiii, 12♂). This was described from Celebes and Australia, but in the 'Genera Insectorum', Celebes only is given. In the British Museum is a specimen from Mabille's collection with a Mabille label "*P. rectivitta* P. Mb. Nov. Holl." This is very probably the male holotype and is certainly our northern race. There is no race of *sunias* in Celebes. The other Australian races are *nola* Waterh., 1932, Pl. xxxiii, 13♂, 13A♀, from New South Wales, and *sauda* Waterh., 1937, from Port Darwin. Holotype males of both at Sydney.

#### ARRHENELLA, nom. nov.

This name is introduced to replace *Arrhenes* as used by myself (Waterh., 1932, p. 251) and Evans (*Entom.*, 1934, p. 206). *Arrhenes* was first mentioned by Mabille in the *Genera Insectorum*, 1904, p. 142, as a manuscript synonym of *Ocybadistes* Heron. Mabille does not mention *O. walkeri*, the genotype of *Ocybadistes*, and his description is based on *marnas*. The use of *Arrhenes* by Evans and myself is incorrect, as that name can only be considered as a synonym of *Ocybadistes* Mab., nec Heron.

*Arrhenella* differs from its allies in having much broader wings and in the shape of the antennal club which is gradual and not sharply bent. The male has a discal stigma. Genotype *Pamphila marnas* Feld., 1860.

*A. marnas affinis* Waterh. and Lyell, 1912 (W. and L., 1914, 885♂; Waterh., 1932, Pl. xxxiii, 6♂), is the Australian race. Holotype male from Kuranda, Qld., at Sydney. This is the smaller and rarer of the two similar species of the genus found in Australia. Races of *marnas* are found in New Guinea and the Moluccas.

*A. collatus iris* Waterh., 1932 (W. and L., 1914, 704♂, 886♂; Waterh., 1932, Pl. xxxiii, 5♂), is the Australian race. Holotype male from Kuranda, Qld., at

Sydney. Plötz described *collatus* from Delagoa Bay, but all the other species in the same paper are eastern and his coloured drawing shows it to be from New Guinea.

TELICOTA Moore, 1881.

Orthotype, *Papilio augias* Linn., 1767. For a short time *Astycus* Hb. was used instead of *Telicota*, but that usage has been shown to be incorrect. As these species are very similar and difficult to distinguish from one another, I can only follow Evans in his papers in the *Entomologist* for 1934. Females are even more difficult to separate.

A.—Uncus undivided.

*T. eurotas* Feld., 1860, from Amboina. The Australian races are *curychlora* Lower, 1908 (W. and L., 1914, 692♂, 693♂, 861♂; Waterh., 1932, Pl. xxxiv, 8♂, 8A♀), from New South Wales, and *laconia* Waterh., 1937, from Cairns, Qld. Holotype males of both at Sydney.

B.—Uncus divided to base. Forewing vein 3 markedly nearer to vein 2 than to vein 4.

*T. augias argeus* Plötz, 1883 (Waterh., 1932, Pl. xxxiv, 3♂, 3A♀), from Cape York, is the Australian race of this widely distributed species.

*T. antisodesma* Lower, 1911 (W. and L., 1914, 701♂, 862♂; Waterh., 1932, Pl. xxxiii, 18♂, 18A♀).—Holotype male from the Richmond River, N. S. Wales, at Adelaide. This rare species has not been found in North Queensland and the sexes are very different.

C.—Uncus divided to base. Forewing vein 3 about midway between veins 2 and 4.

*T. krefftii krefftii* Macleay, 1866 (W. and L., 1914, 868♂; Waterh., 1932, Pl. xxxiv, 4♂).—Holotype male at Sydney. The unpublished fig. 705 by Plötz of *Hesperia augustula* H-Sch., 1869 from Cape York is this species, which ranges from China to Australia. The race from Port Darwin is *argilus* Waterh., 1933. Holotype male at Sydney.

*T. ancilla* H-Sch., 1869 (W. and L., 1914, 683♂, 702♂, 703♀; Waterh., 1932, Pl. xxxiv, 5♂, 5A♀).—The female is *olivescens* H-Sch., 1869. Both are described from Rockhampton. The range of this species coincides with that of *krefftii* for about 200 miles in Queensland and it extends to the south of Sydney.

D.—Uncus divided to base. Forewing vein 3 nearer to vein 4 than to vein 2.

*T. mesoptis mesoptis* Lower, 1911 (W. and L., 1914, 869♀; Waterh., 1932, Pl. xxxiv, 6♂, 6A♀).—Holotype male from Kuranda, Qld., at Adelaide. Typically from North Queensland, but races occur in New Guinea, Key and Aru.

*T. brachydesma* Lower, 1908 (W. and L., 1914, 671♂, 672♀, 878♂, 879♀; Waterh., 1932, Pl. xxxiv, 7♂, 7A♀).—Holotype male from Cooktown at Sydney. A rare species, confined to Australia.

*T. ohara ohara* Plötz, 1883 (W. and L., 1914, 685♂, 696♂, 697♀; Waterh., 1932, Pl. xxxiv, 2♂).—Described from a female from Cape York, holotype probably lost. Occurs elsewhere in the New Guinea area.

CEPHRENES Waterhouse and Lyell, 1914.

This genus was proposed in place of *Corone* Mab., 1878, which is preoccupied. Its genotype is *C. ismenoides* Mab., 1878, a race of *Pamphila augiades* Feld., 1860.

*C. augiades* Feld., 1860.—Typically from Amboina, two races are found in Australia. The southern is *sperthias* Feld., 1862 (W. and L., 1914, 679♀, 682♀; Waterh., 1932, Pl. xxxiii, 17A♀). Holotype male from Sydney could not be found



at Tring. The male has small spots in 4 and 5 on the upperside of the forewing. The female is well marked on the upperside, although rarely specimens are found with the markings reduced. These are *ulama* Butl., 1870, holotype in the British Museum. Mathew, 1888, described the early stages of this race under the name of *phineus* Cram., a Surinam species. Olliff and Forde, 1891, used the same name in the text and *palmarum* Scott on the plate. The northern race is *ismenoides* Mab., 1878 (W. and L., 1914, 678♂, 680♀, 681♂; Waterh., 1932, Pl. xxxiii, 17♂, 17B♀), based on a female without markings on the upperside. This holotype is in the British Museum, and I would assign the locality Cooktown for it. The male is without a spot in 5 on the upperside of the forewing, and the spot in 4 is usually smaller than in *sperthias*. This species has the end of the uncus bidentate.

*C. trichopepla* Lower, 1908 (W. and L., 1914, 676♀, 677♂; Waterh., 1932, Pl. xxxiii, 16♂).—Holotype male from Mackay, Qld., at Adelaide. This species has the end of the uncus tridentate.

#### SABERA Swinhoe, 1908.

Orthotype, *Hesperia caesina* Hew., 1866. The three Australian species of this genus are all different in appearance, but all have much longer antennae than the others in the group. In the male, *albifascia* has a small patch of sex scales within the white spot in 1a of the forewing above, *autoleon* a broken stigma, and *fuliginosa* a complete stigma. Races of all are found beyond Australia.

*S. caesina albifascia* Misk., 1889 (W. and L., 1914, 566♂, 569♂; Waterh., 1932, Pl. xxxiv, 15♂).—Holotype male from Herbert River, Qld., at Brisbane.

*S. orida fuliginosa* Misk., 1889 (W. and L., 1914, 737♀; Waterh., 1932, Pl. xxxiv, 16♂).—Holotype female from Cardwell, Qld., at Brisbane.

*S. dobboe autoleon* Misk., 1889 (W. and L., 1914, 694♂, 695♂; Waterh., 1932, Pl. xxxiv, 1♂).—Holotype female from Cardwell, Qld., at Brisbane, and not a male as stated by Miskin. No mention is made of a stigma in his description.

The following species have been recorded from Australia with a definite locality.

*Pyrurgus argina* Plötz, 1884, *Mitth. Nat. Ver. Neu-Pomm.*, p. 22, Brisbane.—I have seen a copy of the coloured drawing of Plötz and also the figures in Seitz, where it is stated to be a *Bibla*. It does not resemble any known Australian skipper, and if it were from Brisbane it should have been found again.

*Hesperilla rietmanni* Semper, 1878, *Journ. Mus. Godeffroy*, xiv, p. 187.—A male and a female described from Sydney, caught in February. It is a small species, but I have never been able to determine what it is. It may possibly be *compacta* Butl., especially the female. Semper compares the male to *picta*, but he seems to have identified that species wrongly.

*Hesperilla bifasciata* Tepper, 1882.—The figure is very poor and seems to resemble a moth rather than a butterfly. In 1890 Tepper suggested it might be *flavovittata* Latr., but the figure could not possibly be that species.

*Oriens augustula* H-Sch., 1869.—This was described from Fiji. The specimens in the Hewitson collection labelled Port Denison are certainly from Fiji. The Townsville male at Adelaide was no doubt caught at Townsville. An occasional straggler may be caught in Australia, but it has failed to establish itself here.

*Hasora celaenus lugubris* Boisd., 1832.—There is a very poor male at Adelaide from Cape York. If the record is correct, it is undoubtedly a straggler from New Guinea where it is common.

Most of Mabilie's species described in 1891 have been mentioned above, except the following:

*Hesperilla eactis* is the common *Baracus vittatus* Feld. from Ceylon. Mabilie, 1904, agrees to this.

*Hesperilla sarula*.—Holotype female in Berlin Museum shows it is not Australian.

*Pamphila lagon*.—Holotype male in Berlin Museum shows it is not Australian.

*Padraona suborbicularis* Mab., 1904, is a *Dalla* from South America.

*Ocybadistes suffusus* Mab., 1904, is the male of *Telicota melanton* Mab., 1878, from New Guinea and has not yet been caught in Australia.

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REVISION OF THE GENUS *FERGUSONINA* MALL. (DIPTERA,  
AGROMYZIDAE).

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(Communicated by Dr. G. A. Currie.)

(Sixteen Text-figures.)

[Read 30th June, 1937.]

Although the genus *Fergusonina* has been erected within recent years by Malloch (1924), a revision of it has already become necessary on account of the many species brought to light by the work of Dr. G. A. Currie on the early stages of these interesting gall makers. No less than 19 species are now known to us, many of which would not have been easily detected but for the evident specific characters exhibited in the larval stages and also, in many instances, by the shape of the gall. There is no doubt that a large number of other species are awaiting discovery, since each species of *Eucalyptus* seems to have its corresponding species of *Fergusonina*, and even in some instances several of them, according to the part of the tree on which the galls are found.

As many of the newly-discovered species could not readily be distinguished from the seven known ones by means of the few characters, mainly of coloration, used by Malloch in his descriptions, a more complete study, including the genitalia of all the species, and especially of the known ones, became imperative. This revision was greatly facilitated through Mr. Malloch's kindness in making his types available to the writer; they will eventually be returned to the institutions from which he had received them for study.

The seven species described by Malloch are: *F. microcera*, genotype (♀ 1924, ♂ 1926; gall unknown), *F. atricornis* (♂ 1925; gall unknown), *F. flavicornis* (♀ 1925; gall unknown), *F. scutellata* (♂ 1925; gall unknown), *F. biseta* (♂ 1932, from galls of *E. maculata*), *F. gurneyi* (♂, ♀ 1932, from galls of *E. maculata*), *F. eucalypti* (♂, ♀ 1932, from galls of *E. maculata*).

All except the last two were described from single specimens; both sexes of *F. eucalypti* and *F. gurneyi* were obtained through breeding from a certain type of gall, but the two sexes of *F. microcera* have been collected in the field, in different localities, near Sydney. It is therefore doubtful whether they actually belong to the same species since the multiplicity of forms is so great. The flies of both sexes given as belonging to the same new species described in this paper have always been obtained from the same type of galls on the same host; it is, therefore, very likely that the correlation is correct. All errors are, however, not completely excluded by this method, since two species, such as *F. eucalypti* and *F. gurneyi*, may sometimes breed in very similar galls on the same part of the tree.

It is remarkable that none of the twelve new species bred recently from known galls can be referred to any of the seven described species, yet the localities of some of them are not so very far apart; this shows that the number of species must be very large indeed.

## Genus FERGUSONINA.

The original diagnosis of the genus was made by Malloch (1924, p. 337) on a single female specimen, the venation of which is very probably aberrant, and the head chaetotaxy an exception among the many other species. This diagnosis was supplemented and corrected further by that author in 1925 (p. 90) and then in 1932 (p. 213), and it stands in need of further emendation and addition since the discovery of many other new species. In view of these successive modifications, it seems best here to give a full description of the generic characters as drawn from the older species and those that have come to light recently.

*Head*.—Face conspicuously flattened, lunula unusually developed, antennae small, separated by a strongly developed carina and inserted in deep pits at the level of the lower margin of the eyes, but quite distant from these. Antennae almost bare, a few tiny hairs and one stiff but short bristle on the 2nd segment. Arista usually incrassate at base, more or less elongated and more or less stiff, sometimes the distal part flagelliform, almost always distinctly pubescent. Proboscis small, palpi moderate. Chaetotaxy: vibrissae always well developed; parafacials, frons and vertex covered with small stiff hairs; almost always two orbitals, seldom only one, the posterior ones larger; sometimes in between them one or two short hairs, slightly larger than those of the vertex and pointing in the same direction as the true orbitals; sometimes also one of these small hairs in front of the anterior orbital, or behind the posterior one. Two pairs of verticals, the inner ones smaller, convergent, the outer ones divergent; the ocellars proclinate and parallel, the postverticals against the ocellar triangle, erect, parallel.

*Thorax*.—Mesonotum with numerous small stiff hairs fairly regularly distributed; almost always three, sometimes four, distinct prescutellar dorso-centrals, the anterior ones sometimes very small and difficult to detect. One pair of prescutellar acrosticals present, sometimes not much larger than the hairs of the mesonotum; often another small bristle in between the acrosticals and the last dorso-central. One or two prealar and postalar, one humeral, one post-humeral and two notopleural bristles. Mesopleurae setulose, one larger bristle on the upper margin, sometimes a second one, always smaller. Mesosternum setulose with one larger bristle on upper margin.

*Legs* with tiny stiff hairs; a row of postero-ventral bristles on the anterior femora; one large postero-ventral bristle on the hind femora.

*Wing*.—Costa apparently unbroken at base except near h, extending past the tip of  $R_{2+3}$  and sometimes reaching the tip of  $R_{4+5}$ , but in that case its fine bristles are not always present up to that point, so that the costa seems, at first sight, to go only up to a little distance beyond the tip of  $R_{2+3}$ . The two branches of  $R_s$  are usually parallel, but may also be convergent. The posterior cross-vein may be missing (as in *Phytomyza*) either completely or it may be represented by a very small stump on M. The distance between the two cross-veins is usually equal to the length of the posterior cross-vein, but it is, in a few instances, either smaller or larger.

*Abdomen* fairly flattened ventro-dorsally. Hypopygium of male inconspicuous, folded under the venter;\* it is composed of a rounded capsule, the 9th tergite,† with which the coxites are fused and are therefore not able to move independently.

\* *F. microcera* may constitute an exception in this respect, since Malloch described the forceps as being long and protruding; I have not seen this species.

† In one species, *F. newmani*, the 8th tergite also enters in the composition of the hypopygial capsule (fig. 11B).

These coxites assume the shape of ventro-lateral, more or less developed, lobes or flaps which may or may not be divided by a deep cleft from the capsule of the 9th tergite. Sometimes these flaps, instead of being rounded, are provided with a conspicuous apical tooth (figs. 9, 15, 16), and between them and the sub-anal lobe there is at times a conspicuous, rather strongly sclerotized tooth (figs. 11, 13). The flaps are often provided on their inner face with a number of sensory setae. The dorsum of the 9th tergite carries a fair number of small stiff bristles and a pair of very long ones at the base; they are usually cruciate (figs. 11, 12, 16). The 9th tergite and its ventral flaps almost completely surround the distal end of the aedeagus or intromittent organ. The aedeagus is composed of a rather complex basal part comprising the ejaculatory apodeme which is not an independent piece as in many Acalyptratae and in *Agromyza* for instance, but it is attached by a transverse sclerotized bridge to a large shield-like piece (fig. 3A) enclosed within the abdominal cavity and which I very doubtfully consider as an apodeme of the 9th sternite; the intromittent organ is composed of a median duct, evidently the penis, and a dorsal semi-cylindrical piece apparently constituted by the longitudinal fusion of two symmetrical elongate organs (the parameres?) which form the hypophallus; near the extremity of the penis there is, on each side, an articulated, often toothed, organ which is analogous to the titillator of certain chalcid wasps. When the intromittent organ is dissected these two "titillators" remain attached to the penis; I take them to be the paraphalli. Normally they are also attached by their externo-basal corner to the hypophallus, so that when the penis slides forward on the latter the paraphalli are tipped sideways (figs. 2, 3); their function is apparently to serve as anchorage during copulation. The shape and structure of these paraphalli are peculiar to each species; they often offer a better means of identification than the ventro-lateral flaps, which do not always come out well on the preparations; but to obtain a good view of the paraphalli it is necessary to dissect the aedeagus out of the 9th tergite before mounting.

In the female the distal end of the abdomen is highly modified, even the 6th segment being involved in the formation of the ovipositor; this segment is sub-cylindrical, its tergite and sternite being fused so as to form a strongly chitinated tube without lateral suture; it carries a number of submarginal bristles arranged in one dorsal and one ventral group, in which the number of bristles and their arrangement differ according to species, or group of species. The 7th segment is fusiform, still more strongly sclerotized; it also carries a number of sub-apical bristles and, exceptionally, some more bristles on the bulb, either ventrally or dorsally.

These two segments constitute the external part of the ovipositor, but sometimes, at least after death, the 8th segment protrudes and the whole organ assumes then a much more elongate appearance (figs. 4, 5, 10). The 8th segment is normally invaginated completely within the 7th; it is membranous, but most of its surface is covered with dense triangular teeth directed backwards. The 9th segment is very long and stylet-like, gently curved, and ends in an acicular point; its musculature is attached to a very long rod-like apodeme of the 7th segment which projects a long way within the 6th segment.

#### *Status of the genus Fergusonina.*

In his first paper Malloch placed this genus in the Agromyzidae, subfamily Agromyzinae, without discussing in any way the family or subfamily status of his new genus.

If one is to follow Hendel in giving such a great importance to the breaks in the costa in the taxonomy of the Acalyptratae, *Fergusonina* could not find its place in the Agromyzidae because there is no such break in the vicinity of the tip of  $R_1$ . There is only one slight break, or trace of such, in the vicinity of  $h$ , such as is found in the Trypetidae, Milichidae, Carnidae, and a few others, but in all these families there is also a distinct break at  $R_1$ .

*Fergusonina* stands apart among the Agromyzidae in the absence of the lower orbital bristles; the post-vertical bristles sub-parallel, erect, not strongly divergent and pointing backwards; by the conformation of the abdomen which has only five visible segments before the genitalia in both sexes, since the 6th in the female is, in a way, a part of the ovipositor. The conformation of the male hypopygium is also quite different from that of the Agromyzidae; the female ovipositor is more akin to that of the Trypetidae, but yet not fundamentally different from that of *Phytomyza*, for instance (some species also lack the posterior cross-vein as in this genus), in which the 8th segment is also of a raspy nature; however, in *Fergusonina* the 9th segment is stylet-shaped as in the Trypetidae.

I am giving here a list of the characters of the Agromyzidae as set out by Hendel (1928) and by Hering (1927), so that one might, by comparison with the detailed description of the genus *Fergusonina* I have given above, easily appreciate how far this genus differs from the other members of the family:

(1) Costa interrupted in front of tip of Sc or  $R_1$ ; (2) Sc obsolete, ending in costa or in  $R_1$ ; (3) costa reaching to  $R_{4+5}$  or  $M_1$ ; (4) anal and anal cell always present; (5) vibrissae and inferior orbitals always present; (6) when vibrissae absent the costa only reaches the tip of  $R_{4+5}$  and the lateralia and vertical plate are widened in front and strongly hairy; (7) posterior cross-vein present or absent; (8) several dorso-central bristles; (9) acrosticals present or absent; (10) facial carina present; (11) antennal pit reaching the epistome; (12) palpi small; (13) presutural bristles present; (14) prescutellar bristles present; (15) postvertical bristles not convergent; (16) no bristle on frontal band (interfrontalia); (17) abdomen with six visible segments before the genitalia in both sexes; the 7th segment forms the non-retractile part of the ovipositor, its tergite and sternite being fused in a single tube in which the rasp-like 8th and the soft 9th segments are withdrawn.

Many "families" have been erected in the past in the Haplostomata with less grounds than *Fergusonina* would have to be included in a family of its own; yet, as its affinities evidently point to the Agromyzidae, I propose to erect only a new subfamily within this group to receive this genus. This procedure will more readily suggest the affinities, without introducing another family in this already over-divided group.

To sum up, the new subfamily of the Fergusoninae is characterized as follows: Costa without break at tip of Sc or  $R_1$ , but with a trace of one at  $h$ , only two or even one posterior orbital bristle; antennae inserted very low on the face; lunula extremely developed; only five abdominal segments before the genitalia; 6th abdominal segment in the female forming part of the ovipositor, the 9th segment stylet-shaped.

The key to species given below will only work for the species known to me; it will have to be remodelled as further species are added to the list. It is almost completely based on coloration; this is a serious weakness, but it will allow identification of a fairly large number of species without dissection of the genitalia. However, unless the specimens studied have been bred from galls of

a known species of *Eucalyptus*, dissection of the genitalia will have to be resorted to in the end, in order to obtain an accurate identification. The grouping of the species follows the order given in the key; it is purely artificial, since it rests mostly on characters of coloration. No sound grouping could really be attempted until most of the large number of species, which await discovery, are brought to light.

At Dr. Currie's request all the new species have been named after persons who have procured him material or have otherwise helped him with his work.

The types of *F. microcera*, *atricornis*, *flavicornis* and *scutellata* are in the collection of N.S.W. Dept. of Health, Sydney; those of *F. biseta*, *gurneyi* and *eucalypti* in the collection of the Entomological Branch, Dept. of Agriculture, Sydney; and those of all the new species described in this paper in the collection of the C.S. & I.R. at Canberra.

Key to Species.

1. Antennae partly black or brownish ..... 2
- Antennae completely yellowish ..... 4
2. Third antennal segment black or brown, orbital bristles very small ..... 3
- Second antennal segment blackish-brown, sometimes rather faintly; four complete dark vittae on the mesonotum and longitudinal blackish streaks on pleurae; orbital bristles well developed ..... *F. carteri*, n. sp.
3. Mesonotum shining without dark vittae or markings; parafacials wide, with two rows of setulae; wing-length 3 mm. .... *F. eucalypti* Mall.
- Mesonotum dull, with dark markings on the side past the suture; wing-length 2.2 mm. .... *F. atricornis* Mall.
4. Posterior cross-vein missing or represented only by a very small stump on the median vein\* ..... 5
- Posterior cross-vein complete ..... 6
5. Genitalia as in fig. 4 ..... *F. evansi*, n. sp.
- Genitalia as in fig. 5 ..... *F. davidsoni*, n. sp.
6. Legs extensively dark or with a few small dark markings ..... 7
- Legs completely yellow ..... 9
7. Mesonotum black with exception of the side margins, dark markings on the femora only ..... *F. scutellata* Mall.
- Mesonotum mostly yellowish-orange or else the four dark vittae are not fused together and the area in front of the scutellum is yellow ..... 8
8. Legs with small dark markings on the tibiae only ..... *F. brimblecombi*, n. sp.
- Legs with extensive black markings on the femora and tibiae, hypopygium blackish ..... *F. morgani*, n. sp.
9. Mesonotum extensively dark or with four almost complete dark vittae ..... 10
- Mesonotum without dark markings or at most with a few faint ones past the suture ..... 15
10. Mesonotum extensively dark, the dark vittae being fused or almost fused and extending to the scutellum ..... 11
- The dark vittae well separated, or if fused the area in front of the scutellum is yellowish ..... 12
11. The mesonotal vittae completely fused ..... *F. scutellata* Mall.
- The vittae distinctly separated by very thin yellow streaks ..... *F. gurneyi* Mall.
12. No dark markings on pleurae or alae, or else they are small and faint ..... 13
- Dark markings on pleurae extensive ..... 14
13. Four complete dark vittae on the mesonotum, the lateral ones not split longitudinally past the suture and not extending on the alar callus ..... *F. pescotti*, n. sp.
- The four dark vittae somewhat interrupted before the suture, the lateral ones split past the suture so that there appear to be six vittae across the middle of the notum ..... *F. flavicornis* Mall.
14. Median vittae of mesonotum interrupted in their middle, area in front of scutellum and sides of the latter infuscated; mesopleurae almost completely dark; 8th abdominal tergite present in male and as big as the 9th .... *F. newmani*, n. sp.

\* *F. microcera*, whose type is the only known specimen, has the posterior cross-vein obsolete on one wing only; it is not placed in this section.

- Median vittae complete and fused with the lateral ones; area in front of scutellum yellow; mesopleurae dark on their upper and lower margins; 8th abdominal segment apparently missing in the male ..... *F. lockharti*, n. sp.
15. Thorax entirely yellowish or orange without trace of darker vittae on the mesonotum past the suture or dark markings on the pleurae ..... 16  
Mesonotum with a few dark markings past the suture\* ..... 19
16. Orbital and ocellar bristles very small, distance between the two cross-veins shorter than the anterior cross-vein ..... *F. frenchi*, n. sp.  
These bristles of normal length, distance between the two cross-veins sub-equal to the length of the posterior cross-vein ..... 17
17. Only one orbital bristle ..... *F. microcera* Mall.  
Two orbital bristles present ..... 18
18. Femora rather incrassate, wing length 2.5 mm.; hypopygium as in fig. 13 ..... *F. biseta* Mall.  
Femora normal, wing length 2 mm.; hypopygium as in fig. 14 ..... *F. nicholsoni*, n. sp.
19. Wing-length 2.5 mm. in male, 3 mm. in female, dorsum of abdomen nearly completely black; 6th abdominal segment mostly black in female; hypopygium as in fig. 15 ..... *F. curriei*, n. sp.  
Wing-length 2.2 mm., dorsum of abdomen mostly yellow, base only of tergite brown; 6th abdominal segment mostly yellow in female; hypopygium as in fig. 16 ..... *F. tillyardi*, n. sp.

1. *FERGUSONINA CARTERI*, n. sp.

♂. *Head* lemon-yellow, ocellar triangle brown, frons very slightly infuscated anteriorly. Base of antennae deep black, 3rd segment orange, arista black, rather thick and long, sub-nude. Vibrissae and all the hairs of the face and frons black. Two supra-orbitals somewhat longer than the ocellars; sometimes a very small bristle between them pointing outwards. Upper part of occiput behind each eye brownish. *Thorax*: Mesonotum orange-yellow, somewhat shining, slightly grey-pruinose when seen from in front, with four wide blackish vittae, the lateral ones split longitudinally behind, the median ones reaching posteriorly to the last third of notum. Scutellum lemon-yellow; pleurae yellow with a well-marked longitudinal black streak; hypopleurae with a small and slight infuscation; post-notum blackish. Three pairs of dorso-ventral bristles and only one pair of prescutellar acrosticals. *Legs* completely yellow, all the hairs and bristles entirely black. *Wing*: Costa almost reaching tip of  $R_{4+5}$ , but devoid of setulae soon after tip of  $R_{2+3}$ ; the two branches of  $R_s$  parallel; the distance between the two cross-veins equal to the length of the posterior cross-vein. *Abdomen* dull black dorsally except at base and on posterior half of 5th segment; 4th segment very narrowly margined with yellow; hypopygium yellow. Flap of the 9th tergite not divided from it; paraphalli with four teeth, one large apical one and three smaller lateral ones and without any sensory pits or pores (fig. 1B). Wing-length 3 mm.

♀. Completely similar to male; hind margin of 5th abdominal segment broadly yellow, the 6th completely dull yellow, the 7th shining black; the chaetotaxy as in fig. 1C. Type, allotype and numerous paratypes bred from leaf galls of *E. Stuartiana* in Canberra in July, 1934.

A number of specimens bred from galls of *E. amygdalina* from Emerald (Vic.) by Mr. C. French on 11th October, 1906, appear to belong to this species; the genitalia of both sexes correspond well, but the second segment of the antennae is sometimes only slightly infuscated and not deep black. The same species has been obtained from an undetermined species of *Eucalyptus* in Adelaide by Mr. J. W. Evans.

\* The alternative should always be tried, as these markings may be absent in less mature specimens.



## 2. FERGUSONINA EUCALYPTI Mall.

PROC. LINN. SOC. N.S.W., lvii, 1932, p. 214.

♂. *Head* yellow, ocellar triangle with black spots on the inside of each ocellus; 3rd antennal segment black, the arista entirely black, thin, not incrassate at base, distinctly pubescent. The orbital bristles are very small, scarcely distinguishable from the other hairs of the vertex; they are, however, as long as the ocellars and the inner verticals. Vibrissae very small, entirely black, all the hairs of cheeks, face and frons, black; three rows of hairs on the parafacials which are correspondingly wider than usual. *Thorax*: Mesonotum brightly shining rufous-orange, without dark vittae except on the anterior margin, just above the neck, where there is a trace of the fused median vittae. Pleurae without dark markings, postnotum brown. Only two distinct dorso-centrals; four

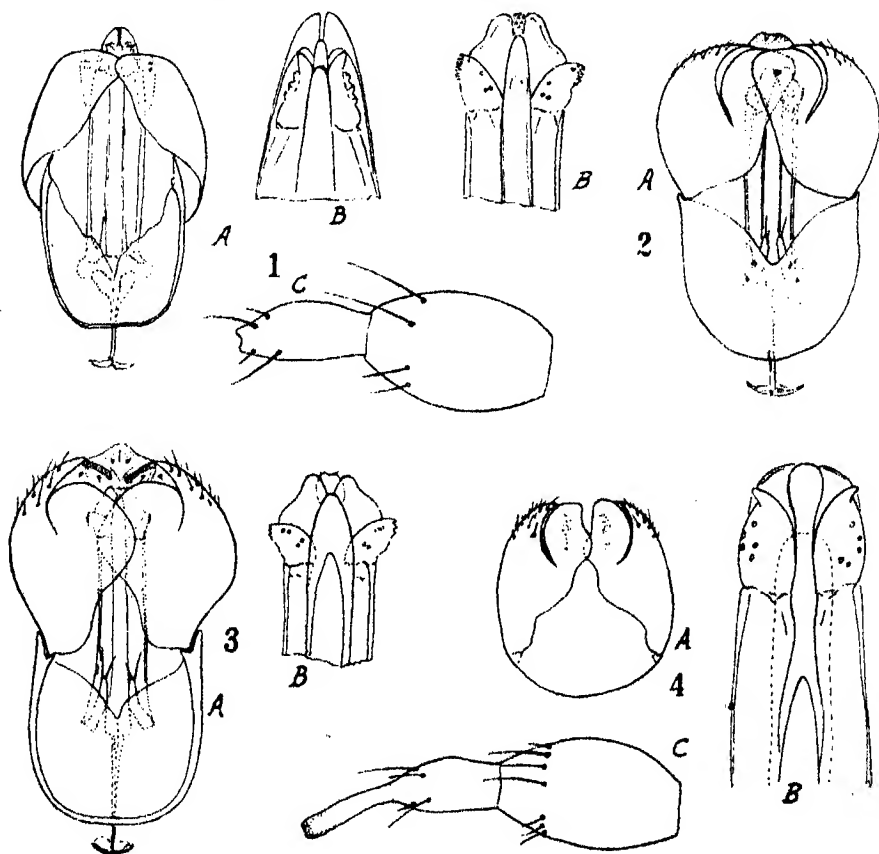


Fig. 1.—*Fergusonina carteri*, n. sp. A, male hypopygium from below; B, tip of intromittent organ; C, ovipositor.

Fig. 2.—*Fergusonina eucalypti* Mall. A, male hypopygium from below; B, tip of intromittent organ, the paraphalli exerted.

Fig. 3.—*Fergusonina atricornis* Mall. A, male hypopygium from below; B, tip of intromittent organ, the paraphalli exerted.

Fig. 4.—*Fergusonina evansi*, n. sp. A, ninth tergite of male from below; B, tip of intromittent organ; C, ovipositor with the 8th segment protruding.

other prescutellars, a short setulose hair behind the supra-alar. *Legs* yellow. All the hairs and bristles, even those of the coxae, black; the hind femora with the usual preapical antero-ventral bristles. *Wing*: Costa actually reaching the tip of  $R_2$ , but appearing to stop in between the two branches of the radial sector because its black spinulae do not reach any further; the branches of  $R_2$  slightly convergent in distal half; distance between the two cross-veins distinctly greater than the length of the posterior cross-vein. *Abdomen* with a large transverse black band in the middle, which spreads on the dorsum of the second to fourth tergites. Hypopygium yellow, its ventral flaps much developed and distinctly separated from the 9th tergite; the paraphalli are multidentate distally and have three sensory pores arranged as shown in figure 2B (these organs are represented there somewhat extruded, not in their normal position); between the two distal lobes of the hypophallus there is a number of characteristic sensory cones. This hypopygium is very similar to that of *atricornis* on account of the development of the flaps; the distal strongly sclerotized pieces shown in figure 3A are also present here, but are not figured as they are hidden by the flaps on account of the position of the whole organ in the preparation. Wing-length 3 mm.

♀. Three orbitals very small and near each other; there is no trace of reddish vittae on the mesonotum. The abdomen is brown on the dorsum of segments II to IV and base of V, the sixth slightly infuscated at the base dorsally, the seventh rather dull black. The vestiture of ovipositor is unusual; on segment VI there are 6 submarginal dorsal bristles, the outside ones being larger, and 4 to 5 submarginal dorsal; besides these there are, on each side before the submarginal bristles, two groups of small setulose hairs; one dorso-lateral, of 4 to 5, and one ventro-lateral, of 5 to 6 hairs. On segment VII, besides the usual long apical bristles, there are some fairly numerous smaller bristles on the bulbous part of the segment, about 20 above and 10 below.

This species was obtained from bud galls of *E. maculata* at Bodalla, N.S.W., in October, and at Bateman's Bay, also in October, by W. L. Morgan. I have seen the holotype male, the allotype, and another female paratype; there is no distinct trace of reddish vittae on the mesonotum, as stated by Malloch; what may appear to be such are the muscular bundles visible through the rather transparent integument of the notum.

### 3. FERGUSONINA ATRICORNIS Mall.

PROC. LINN. SOC. N.S.W., 1, 1925, pp. 91, 92, fig. 7.

♂. *Head* yellow, ocellar triangle shining black; base of antennae yellow, 3rd segment deep black, arista entirely brown. The chaetotaxy of the head is remarkable because of the small size of all the bristles except the outer verticals; however, all the usual bristles, as indicated in the generic diagnosis, are present, although difficult to make out. The type shows three orbitals, the median one being somewhat larger than the others and about equal to the inner verticals; the ocellars are a little longer. Only one row of setulae on the lower part of the parafacials which are narrow at that spot. All setulae of face and frons black. *Vibrissae* entirely black. *Thorax* yellow, mesonotum orange, with four very indistinct rufous vittae, visible only in certain positions; the median ones are brown on a small space right above the neck, the lateral ones brownish past the suture; they are divided longitudinally so as to present each the appearance of two narrow dark streaks, the internal one being placed just outside the dorso-central row of bristles. No dark markings on the pleurae; postnotum blackish; three dorso-centrals present, prescutellar acrosticals not distinct. *Legs*: Hind

femora with the usual bristles anteriorly and sub-apically (not posteriorly as given by Malloch). *Wing*: The two branches of the radial sector somewhat convergent (loc. cit., fig. 7), the distance between the two cross-veins equal to the length of the posterior one. *Abdomen* fuscous above, basal segment pale on the middle and on the sides. *Hypopygium* (fig. 3) remarkable by the development of the ventral flaps of the 9th tergite and the presence of the sclerotized rods near the apex of this tergite. The paraphalli (shown somewhat extruded in figure 3B) are characterized by the three distal triangular teeth and the four sensillae arranged in groups of two. Wing-length 2.2 mm.

The type, from Sydney (20th October, 1924), in the collection of the Health Department, Sydney, is so far the only specimen known.

The above description differs somewhat from that given by Malloch, especially in the coloration of the mesonotum, which he describes as having six vittae; the splitting of the two lateral vittae into two dark streaks, as I have observed in other species, may be purely an individual character; moreover, the anterior part of the lateral vittae does not show any signs of longitudinal division. The position of the strong setulae of the hind femora is decidedly anterior and not posterior; Malloch has been deceived here by the position of the median legs which extend towards the back over the hind one; on the mid-femora the setulae are as stated by him.

This species was probably collected with the net by the late E. W. Ferguson; the type of gall it makes is, therefore, not known.

#### 4. FERGUSONINA EVANSI, n. sp.

♂. *Head* yellow, ocellar triangle shining black, arista thin, sub-naked, rufous on basal third, then brown; vibrissae and all hairs of face and frons black; two orbital bristles present, the posterior ones slightly longer. *Thorax* yellow, mesonotum rufous with small brownish markings just above the neck and six small dark spots on the posterior half; the median ones are on the middle of the disc, the next ones further back on the outside of the row of dorso-central bristles, and the outer ones on the sub-alar callus; these spots are the dark pigmented posterior ends of the vittae which are completely coloured in darker species. These markings may be completely or partly absent in paler specimens. Scutellum and pleurae completely yellow, postnotum brown. Usually three pairs of dorso-centrals and two pairs of prescutellars, the median ones larger. *Legs* entirely yellow, all their bristles completely black, including the long ones on the posterior femora. *Wing*: Costa stopping a little beyond the tip of  $R_{4+5}$ ; wing apex rather pointed at the tip of  $R_{4+5}$ ; the two branches of  $R_s$  sub-parallel; posterior cross-vein missing altogether or at most represented by a very faint trace of a spur on  $M_1$ . *Abdomen* dull brown on the dorsum except at base and tip; no pale margins on tergites 2, 3 and 4, the fifth with a very wide yellow margin. *Hypopygium* yellow, its latero-ventral flaps well separated from the capsule of the 9th tergite and with a group of 8 to 10 setulae on their inner side away from their margin. *Aedeagus* as in figure 4B, the paraphalli provided with five sensory pits and with only one apical tooth, no lateral ones. Wing-length 3 mm.

♀. As male, but the mesonotum not marked with brown in the five specimens examined, except right above the neck; the 5th abdominal segment brown at base only and the 6th with a small dorsal brownish patch; the 7th completely black. On segment VI there are 8 dorsal submarginal bristles, the median pair being small, and 4 or 5 ventral bristles. Segment VII with 2 ventral and 2 dorsal pairs. Wing-length 2.7 mm.

Type, allotype and paratypes bred from leaf galls of *E. methodora* collected at Canberra; emerged in October, 1934.

5. *FERGUSONINA DAVIDSONI*, n. sp.

♂. *Head* yellow, frons rufous, ocellar triangle brown; all the hairs of face black, vibrissae rufous at base. Antennae yellow, arista orange-yellow on basal third which is incrassate, the rest brown, not very distinctly pubescent. All the bristles of the vertex, except the outer verticals, of about the same length; in front of the orbitals are 2 to 3 hairs in the same row and of the same size as those of the frons but more rigid. *Thorax* yellow, mesonotum rufous with four dark vittae, the median ones interrupted so that they form two spots, one above the neck and one on the middle of the disc; the lateral vittae narrow and starting from the suture only; pleurae devoid of dark spots; sides of scutellum slightly infuscated, postnotum brown. Only two distinct dorso-centrals. *Legs* yellow. *Wing*: Costa reaching but very little over the first branch of Rs; posterior cross-vein absent on one wing, on the other represented by a small stump on M<sub>1</sub>. *Abdomen* blackish on the dorsum, posterior margin of 5th segment and hypopygium yellow; lateral lobes of 9th tergite well divided from the tergite with a number of submarginal setulae on their inner face (fig. 5B); paraphalli much more elongate than usual, their apex in form of hook (fig. 5C).

♀. Similar to the male, vibrissae entirely black, the markings of the mesonotum almost obsolete, especially those on the disc; posterior cross-vein represented on both wings only by a very small stump on M<sub>1</sub>. Sixth abdominal segment extensively infuscated at the base dorsally and much less ventrally, seven dorsal submarginal bristles (six is probably the normal number), the median and outside ones larger, and six ventral, the two median pairs smaller; seventh segment black with 3 pairs of dorsal and 2 pairs of ventral bristles (fig. 5D). Wing-length 2.5 mm.

Holotype and allotype from Adelaide, 16th October, 1931, J. Davidson, from *Eucalyptus* gall, species not mentioned.

This species is quite distinct from all others here described by the hypopygial structure of the male. The absence of the posterior cross-vein should not be considered as a very safe specific character since it may be absent or present according to the individual, as appears to be the case for the genotype.

6. *FERGUSONINA SCUTELLATA* Mall.

PROC. LINN. SOC. N.S.W., 1, 1925, p. 92, fig. 9.

♂. *Head* yellow, ocellar triangle shining black, frons infuscated anteriorly, occiput extensively brown on each side. Antennae yellow, arista completely black, rather thick, distinctly pubescent. Vibrissae entirely black, as well as all the hairs on the face. All the bristles long, the posterior orbital somewhat longer than the inner vertical. *Thorax*: Mesonotum entirely black with slightly dusty surface, its sides, including the humeri, yellow, base of scutellum blackish, postnotum black, pleurae extensively fuscous or black with exception of upper part of mesopleurae, sternopleurae deep black. Three distinct dorso-central bristles, acrostical prescutellar present. *Legs* yellowish, a slight dark marking on the anterior side of the middle and hind femora. *Wing*: Costa prolonged a little over the tip of R<sub>4+5</sub>; the two branches of the radial sector sub-parallel.\* *Abdomen*: Dorsum

\* These two veins are but slightly converging and not strongly as shown in Malloch's fig. 9; it is much more like his fig. 7 (*atricornis*). If the wing is not viewed perfectly flat these veins may appear more convergent than they actually are.

black with exception of the middle of the 1st segment, a narrow posterior margin on segment 4 and the posterior half of segment 5, which is yellowish. On the sides and ventrally the tergites are more widely margined with yellow, but their base is fuscous. Hypopygium black, 9th tergite rather elongate, its side flaps small, rounded (fig. 6A); aedeagus characterized by the very long and sharp upper tooth of the paraphalli (fig. 6B). Wing-length 2.5 mm.

Holotype: Sydney, N.S.W., 1st January, 1925, E. Ferguson in Coll. Health Department, Sydney. Gall and host unknown.

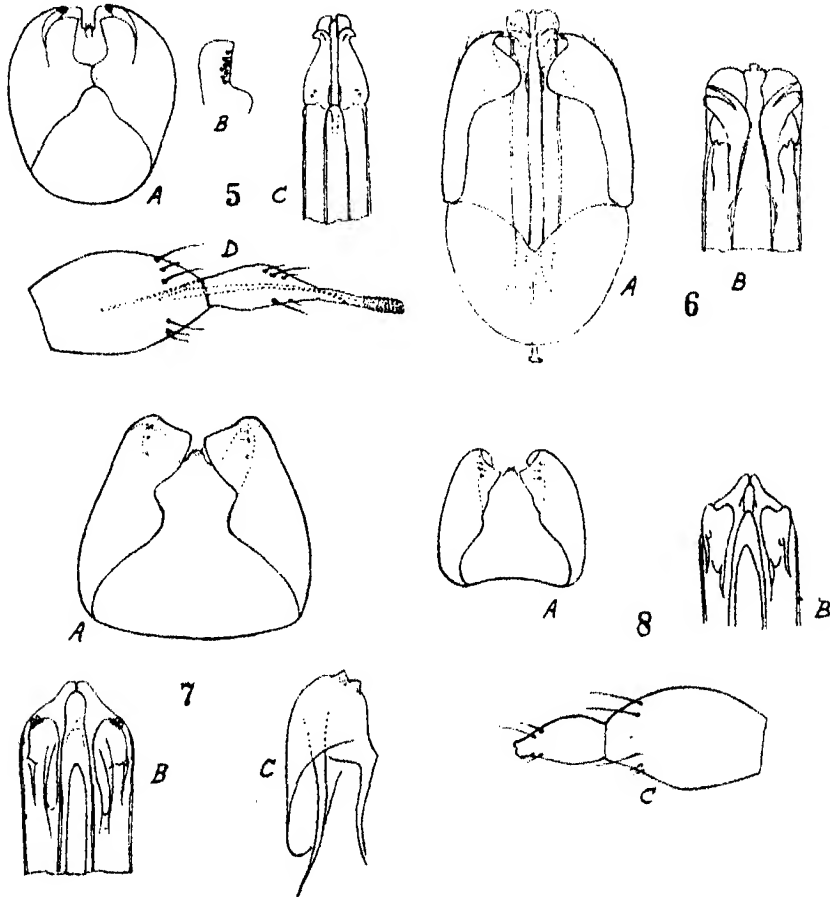


Fig. 5.—*Fergusonina davidsoni*, n. sp. A, ninth tergite of male from below; B, one ventro-lateral flap seen from inside; C, tip of intramittent organ; D, ovipositor with the 8th segment extruded.

Fig. 6.—*Fergusonina scutellata* Mall. A, male hypopygium from below; B, tip of intramittent organ.

Fig. 7.—*Fergusonina grimblecombi*, n. sp. A, ninth tergite of male from below; B, tip of intramittent organ; C, one of the paraphalli dissected out.

Fig. 8.—*Fergusonina morgani*, n. sp. A, ninth tergite of male from below; B, tip of intramittent organ; C, ovipositor.

7. *FERGUSONINA BRIMBLECOMBI*, n. sp.

♂. *Head* yellow with a ferruginous orange crescent above the antennae; ocellar triangle black; antennae completely yellow, arista ferruginous at base on one-sixth of its length, rather thick and short, gradually tapering, not flagelliform, distinctly pubescent. Hairs of face and anterior part of frons pale, vibrissae somewhat infuscated. Two orbital bristles present, the anterior one half the size of the posterior one and sub-equal to the ocellars. *Thorax*: Mainly yellow; anterior half of the mesonotum orange and with one large brown spot split longitudinally just above the neck, a much smaller dark spot on each side just above the shoulder; these spots are the beginning of the four vittae which are completely black in some species; in this one the posterior part of these vittae is ferruginous. Mesopleurae with a longitudinal blackish streak, sternopleurae marked with brown, postnotum black rather shining, pteropleurae and hypopleurae sometimes also brownish. Chaetotaxy of the thorax as usual, the prescutellar acrosticals not conspicuous. *Legs* yellow with a small median black spot on the front and mid-tibiae, more distinct on their anterior side. *Wing* as in *F. pescotti*. *Abdomen*: General coloration yellow with a transverse dorsal brown band across the middle and an apical roundish dark spot; first tergite completely yellow, the 2nd to 4th brownish with narrow pale margin, the 5th narrowly brown at base and with a roundish apical brown spot; hypopygium yellow, ventro-lateral flaps not divided from the 9th tergite, of moderate size and angular at apex with about three sensory setae at base on internal side (fig. 7A), intromittent organ as in figure 7B, paraphalli with two sub-apical teeth inserted somewhat dorsally (fig. 7C). Wing-length 2 mm.

♀. As in male; the 4th abdominal segment with a rather broad posterior margin, the 5th nearly completely yellow but with a median dark vitta which does not extend to the margin; the 6th fuscous at base on both sides of dorsum, not in the middle; chaetotaxy of these two segments as in *F. morgani*.

Holotype, allotype and numerous paratypes bred from flower-bud galls of *E. melanophloia* in December, 1934, at Canberra, by Dr. Currie.

Two female specimens bred from similar galls on *E. crebra* may belong to this species; they correspond in every point, with the exception of the 6th abdominal segment, which is mostly black up to the submarginal bristles.

8. *FERGUSONINA MORGANI*, n. sp.

♂. *Head* yellow, area above lunula orange, ocellar triangle blackish, a dark patch on the occiput behind the upper corner of each eye. Antennae yellow, arista black except at the very base, rather thick and gradually diminishing in thickness, the distal part not flagelliform, distinctly pubescent. Hairs of face and anterior part of frons pale, including the vibrissae. Two supra-orbital bristles, the anterior ones smaller than the ocellars. Mesonotum extensively dark anteriorly, the four vittae being almost fused, the lateral ones are somewhat interrupted at the suture and are split longitudinally past the suture. The median vittae do not extend beyond the middle of the notum. There is a longitudinal dark streak on the mesopleurae; the ptero-, hypo- and sternopleurae are blackish like the postnotum; scutellum lemon-yellow. Three dorso-central bristles present and a pair of very small prescutellar acrosticals. *Legs* yellow with fairly extensive dark markings; femora blackish except at base and apex, the anterior one yellowish on internal face, tibiae with fairly wide median black ring, tarsi yellow. *Wing* as in *F. pescotti*, but the costa distinctly prolonged to the tip of  $R_{4+5}$ , although thinner from a little distance after tip of  $R_{2+3}$ . *Abdomen*: Tergites almost completely black except on

either side of the dorsum of the first one and on the curved lateral part of the second to fourth, where the margin is narrowly yellow and where there is a little yellow patch more ventrally; hind margin of fifth with two very small yellowish areas; 9th tergite blackish. Hypopygium with ventro-lateral flaps not divided from the 9th tergite, their apex angulous, 3 to 4 sensory setae on their internal face (fig. 8A), intromittent organ as in figure 8B, the paraphalli with a bilobed apex, no lateral teeth. Wing-length 2 mm.

♀. As in male; the lateral mesonotal dark vittae sometimes rather narrow after the suture, not split. Fifth abdominal tergite yellow with a black roundish median marking, 6th segment completely black with exception of posterior margin and provided with four long dorsal bristles and six ventral bristles, the 4 median ones being smaller; 7th segment completely black, with two ventral and two dorsal bristles (fig. 8C).

Holotype, allotype and several paratypes from flower-bud gall of *E. hemiphloia*. Collected in Victoria; emerged end of March, 1935.

#### 9. FERGUSONINA GURNEYI Mall.

PROC. LINN. SOC. N.S.W., lvii, 1932, p. 215.

♂. Head yellow, a fuscous anterior margin on the frons, ocellar triangle completely shining black; occiput fuscous on each side. Antennae yellow, arista completely black, distinctly pubescent. Vibrissae very small, entirely black; all the hairs on the face black. Orbitals of equal length, a little longer than ocellars and postverticals. Thorax: Mesonotum with four wide dull-black vittae, leaving only the side margins and very narrow streaks between them yellowish. Median vittae fused in front, somewhat paler brown past the disc, but distinctly reaching the scutellum; lateral vittae also somewhat paler on the alar callus; sides of scutellum brown; postnotum black. A sharp black streak on the mesopleurae (not on anepisternites), mesosternite mostly brown. Three distinct dorso-centrals, two pairs of prescutellars. Legs yellow, the longer bristles of femora entirely black. Wing: Costa reaching only a little way over tip of  $R_{4+5}$ ; the two branches of  $R_s$  subparallel; distance between the cross-veins equal to length of posterior cross-vein. Abdomen: Base of tergites broadly black dorsally; distal half of the fifth yellow. Hypopygium yellow; the flaps of the 9th tergite distinctly separated from the latter distally, their apex acute (fig. 9A). The paraphalli broadly triangular without distinct lateral teeth, but with four sensory pits (fig. 9B).

♀. Similar to male; the abdominal tergites more widely margined with yellow: the 6th segment scarcely infuscated dorsally. Chaetotaxy of the ovipositor as follows: on 6th segment 6 dorsal submarginal bristles, the outer and median ones being larger; further, 6 ventral bristles, the two median pairs much smaller; on 7th segment 2 dorsal pairs, the internal and more distal ones longer, 3 ventral pairs, the proximal pair smaller, the two other pairs at same level, the external ones longer. Wing-length 2 mm.

Holotype and allotype from *Eucalyptus maculata* bud gall, Bateman's Bay, N.S.W., 15th October, 1931 (W. L. Morgan).

All the pale parts of the body of these specimens are dirty yellow as mentioned by Malloch; this is due to their general condition; there is no doubt that the mature individuals are just as bright yellow as usual.

#### 10. FERGUSONINA PESCOTTI, n. sp.

♂. Head yellow, face and anterior part of frons orange, ocellar triangle brown; hairs of face and lower part of frons paler than elsewhere but not very

markedly, vibrissae black. Antennae yellow, arista orange on its thicker basal part, which is less than one-sixth of the dark, flagelliform and distinctly pubescent distal part. Two orbital bristles present, sometimes one, or even two, very small setae in between them. *Thorax*: Mesonotum yellowish-orange with four brown vittae, the median ones extending from the neck to the middle of disc. The lateral ones rather narrow posteriorly (not split as usual). Pleurae orange without brownish markings; postnotum brown. Three dorso-central bristles, the pre-

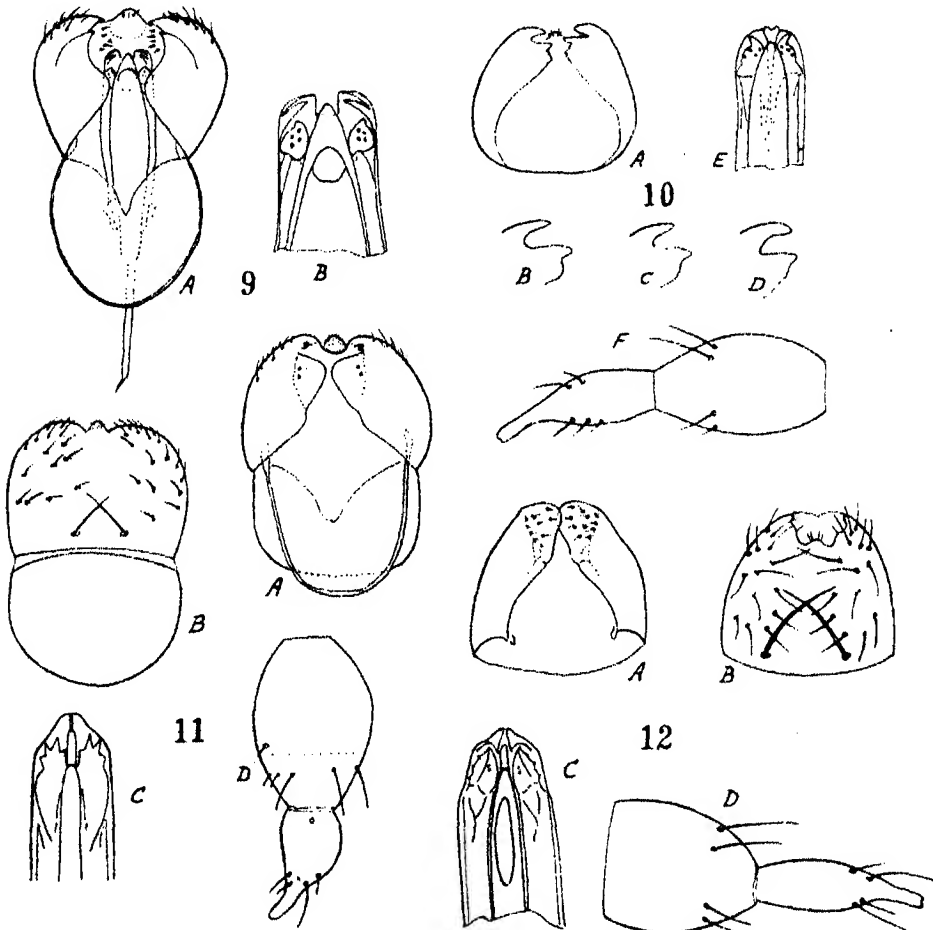


Fig. 9.—*Fergusonina gurneyi* Mall. A, male hypopygium from below; B, tip of intromittent organ.

Fig. 10.—*Fergusonina pescotti*, n. sp. A, ninth tergite of male from below; B, C, and D, various shapes of the ventro-lateral flaps; E, tip of intromittent organ; F, ovipositor.

Fig. 11.—*Fergusonina newmani*, n. sp. A, male hypopygium from below; B, 8th and 9th tergites from above; C, tip of intromittent organ; D, ovipositor.

Fig. 12.—*Fergusonina lockharti*, n. sp. A, 9th tergite from below; B, the same from above; C, tip of intromittent organ; D, ovipositor.



scutellar acrosticals fairly large. *Legs* yellow with black pubescence, bristles of posterior femora slightly pale at base. *Wing*: Costa reaching a little way over the tip of  $R_{2+3}$ ; the two branches of  $R_s$  subparallel; the distance between the two cross-veins a little greater than the posterior cross-vein. *Abdomen* with the dorsum of segments 2 to 4 dark, the posterior margin of the 5th broadly orange, the 1st only partially blackish on the sides. Hypopygium: Latero-ventral flaps completely fused with the capsule of the 9th tergite, each with a strong apical more or less curved tooth and an irregularly dentate process underneath. The outline of this process is very variable, as can be seen from figures 10B, C and D. Tip of the intromittent organ as in figure 10E; paraphalli with one large apical tooth, but no lateral ones and provided with four sensory pits, the two outer ones with setae. Wing-length 2.3 mm.

♀. Similar to male, but the median dark vittae of the mesonotum interrupted in the middle then leaving only two round brown spots on the middle of the disc. Sixth abdominal segment infuscated on the dorsum only and with two pairs of dorsal and of ventral bristles; 7th segment black with two pairs of dorsal and three of ventral bristles. There is some variation in the number of these bristles; the proximal ventral pair of the 7th segment may be missing.

Holotype, allotype and 3 paratypes from Emerald, Victoria, 6th December, 1906, C. French; bred from leaf-gall of *E. amygdalina*. Also, 3 female paratypes from the same locality on 29th March, 1907, and very numerous specimens from Warrandyte (Victoria) bred from unidentified galls by G. F. Hill.

#### 11. FERGUSONINA FLAVICORNIS Mall.

PROC. LINN. SOC. N.S.W., 1, 1925, p. 92.

♀. *Head* yellow, ocellar triangle brown, an infuscated area on each side of occiput; all the hairs of face and frons, including the vibrissae, dark. *Antennae* yellow, the arista orange on its incrassate basal quarter, the rest thin brownish, distinctly pubescent. Two orbital bristles, the anterior one smaller, sub-equal to the ocellars. *Thorax* yellow, ground-colour of the anterior part of the mesonotum reddish-orange and with brown vittae; both the lateral and the median vittae are paler on a small space just before the suture, the lateral ones are split longitudinally after the suture so that there appear to be six vittae towards the middle of the mesonotum; postnotum brown; a very faint brownish spot on the anepisternum and pteropleurae. Chaetotaxy of the thorax as usual, three pairs of dorso-central bristles. *Legs* completely yellow with all bristles and hairs black. *Wing* with costa reaching just a little over the tip of  $R_{2+3}$ , branches of  $R_s$  parallel, distance between the cross-veins equal to the posterior cross-vein. *Abdomen*: Dorsum of all the tergites dull blackish with exception of a very narrow hind margin; the 6th segment brownish dorsally with four dorsal and four ventral submarginal bristles, the median pair of the latter small; 7th segment black, rather elongate, with four dorsal and four ventral bristles. Wing-length 2 mm.

Holotype and unique specimen, Sydney, 30th November, 1924, E. Ferguson.

Malloch described this species as having six black vittae; this is true if one considers only the part immediately behind the suture. Further, he states that there is only one orbital bristle; the unique specimen is not in very good condition—there is on each side only one orbital bristle left, but on one side it is the anterior one and on the other the posterior one; the pores of the missing ones are plainly visible.

This species is not at all characteristic and, as the host species is not known, it may not be easily identified again. It comes very near to *F. pescotti*, and it is possible that this species will prove to be identical with *flavicornis*. However, as only one sex of the latter is known and as galls on *Eucalyptus amygdalina* have not yet been recorded but from Victoria, I think it is advisable for the present to consider both forms as distinct species.

12. *FERGUSONINA NEWMANI*, n. sp.

♂. *Head* yellow, ocellar triangle fuscous with a blacker ring round each ocellus. Antennae yellow, arista rather short, its base rufous; vibrissae and all the hairs of the face black. Two upper orbitals not much longer than the ocellars. *Thorax*: Mesonotum rufous with four brown vittae, the median pair extending to the middle and markedly paler midway between the anterior border and the disc where they appear as two round, blackish spots; area in front of the scutellum fuscous, the latter has the same coloration and its sides have brownish markings at the base. Mesopleurae almost all brownish except in the middle; sterno-, ptero- and hypopleurae marked brownish; postnotum black; halteres yellow.\* Three dorso-central bristles; prescutellar acrosticals very small. *Legs*: Yellow, all the hairs and bristles black. *Wing*: Costa reaching the tip of  $R_{4+5}$  but its black setulae stopping well before that, the two branches of the Rs parallel, distance between the two cross-veins equal to the length of the posterior one. *Abdomen* almost completely black dorsally, the first segment with a few yellowish markings at the base. Hypopygium yellow, its lateral lobes or flaps well developed but not divided from the 9th tergite (fig. 11A); paraphalli with four teeth, the two apical ones elongate (fig. 11C); eighth tergite present, small, and forming with the ninth the hypopygial capsule (fig. 11B).

♀. Similar to male; sixth abdominal segment blackish from the base to somewhat below the level of the sub-marginal bristles, both dorsally and ventrally; seventh segment black, short and bulbous; chaetotaxy of these two segments is depicted in figure 11, which shows them in profile; there is in the allotype a single ventral bristle on the bulb which may not be usually found there. Wing-length 2 mm.

Type and allotype from King's Park, Perth, W.A., bred from gall on leaf-bud of *Eucalyptus gomphocephala* by G. A. Currie, 10th August, 1933. Also, one female paratype from the same locality, rather immature. The type and allotype are preserved in spirit, their genitalia on slides.

13. *FERGUSONINA LOCKHARTI*, n. sp.

♂. *Head* yellow, ocellar triangle black; antennae yellow; arista relatively short, rufous on the basal quarter; vibrissae and all the hairs of the face black. The posterior orbital is distinctly longer; between the two orbitals there is a small coarse hair similar to those of the vertex but it points outwards. Occiput fuscous on the sides. *Thorax*: Mesonotum yellow with four wide black vittae. The median hair on the anterior half of the notum only; lateral vittae split longitudinally after the suture. Mesopleurae with extensive fuscous markings composed of a longitudinal upper streak, some dark blotches underneath and a dark lower margin. Sternopleurae with a large squarish fuscous spot; pteropleurae and hypopleurae partly brownish. Post-notum black. Scutellum lemon-yellow. Four distinct dorso-centrals; two pairs of prescutellar acrosticals of equal length. *Legs*: Yellow, all the hairs and bristles black. *Wings*: Costa reaching the tip of  $R_{4+5}$  but its setulae

\* This coloration is described from specimens in spirit.

stopping just a little over the tip of  $R_{2+3}$  so that, at first sight, the costa may seem to stop there. The two branches of  $R_s$  parallel; distance between the two cross-veins equal to or a little less than the length of posterior cross-vein. *Abdomen*: Whole dorsum black, only a small median area on first segment and a very narrow posterior margin on segments 4 and 5 yellowish; venter and hypopygium yellow. Lateral flaps not separated from the 9th tergite, rounded and provided with about nine sensory setae on the inside (fig. 12A). Intromittent organ shown in figure 12C; paraphalli with small widely-spaced teeth and one or two sensory pits. The structure of this hypopygium is exceedingly close to that of *tillyardi*, but in the latter the teeth of the paraphalli are relatively larger, more closely placed, and somewhat curved backwards; moreover, the dorsal setae of the 9th tergite are weaker and there is more than one setula on the distal edge of the tergite between the median dorsal tubercle and the lateral lobes. Wing-length 2.4 mm.

♀. Similar to male, the sternopleurae not so conspicuously marked with brown. Fifth abdominal segment with a wider yellow margin; the 6th segment blackish dorsally and ventrally at the base, nearly to the level of the submarginal bristles, four of these dorsally and four ventrally; seventh segment black, fairly elongated with two pairs of bristles above and two below. In one female the four black vittae are widely interrupted midway between the neck and suture, the mesonotum is there of a rufous colour.

Holotype, allotype and several paratypes of both sexes in alcohol from Mundaring, W.A., July, 1933, bred from leaf gall of *Eucalyptus rudis* by G. A. Currie.

#### 14. FERGUSONINA FRENCH, n. sp.

♀. *Head* ochraceous-orange, ocellar triangle brown, frons and vertex dull orange; all the hairs and bristles black, vibrissae small. Antennae yellowish, arista orange on incrassate part of base, remainder brown, thin, not distinctly pubescent. The two orbital bristles are very small yet quite distinct from the coarse hairs of the vertex, they are very close to each other (on one side there is a third smaller one posteriorly, in the type). Ocellar bristles of the same size as the orbitals and curved forward in the same way as the other hairs of the vertex, not strongly proclinate; a pair of small setulae right in the middle of the triangle; post-vertexals erect and longer than the orbitals. *Thorax* shining, completely ochraceous-orange, no trace of vittae on notum, the postnotum brown; two large dorso-central bristles and two small ones, prescutellar acrostichals quite conspicuous, a further bristle of same size between these and the dorso-centrals. *Wing*: The two branches of the sector very slightly convergent; the costa ending at the tip of  $R_2$  and bristly up to that point; the distance between the two cross-veins shorter than the length of the anterior cross-vein. *Abdomen*: Dorsum dull black, the posterior corners and hind margin of fifth segment narrowly yellow; the sixth segment dull brownish-black above and below, with six dorsal bristles and four ventral ones, the median pair smaller; seventh segment shining black, with five dorsal pairs of bristles, the two proximal ones small and one of them missing on one side, two ventral pairs. Wing-length 3 mm.

Holotype and unique specimen bred from small leaf galls on *E. amygdalina* from Emerald, Victoria, in October, 1906, by Mr. C. French. This species is similar in size and general coloration to *F. eucalypti* Mall., but it differs from it, at first sight, by completely yellow antennae and the entirely dark sixth abdominal segment, and further by the seventh with a limited number of bristles (four pairs); the orbital bristles are longer, although more reduced than in the majority of species.

15. *FERGUSONINA MICROCERA* Mall.

PROC. LINN. SOC. N.S.W., XLIX, 1924, p. 338; 1, 1925, p. 91, fig. 6.

♀. *Head* yellow, a narrow black ring round each ocellus, the rest of the ocellar triangle yellow; antennae yellow; arista slightly rufous at base and distinctly pubescent. One large orbital only, behind which there is a small coarse hair directed outwards instead of forwards like all the other hairs of the vertex, it is also a little thicker than these and may represent the posterior orbital bristle. Vibrissae ochraceous at base, hair of face with a rufous tinge. *Thorax* completely rufous-yellow, contrasting with the bright yellow of the head, the postnotum somewhat infuscated. A row of five dorso-central bristles, the two anterior ones very small but yet distinct from the coarse hairs of mesonotum; prescutellar acrosticals longer than usual, somewhat more, than half as long as the largest dorso-central. *Legs* yellow, the longer bristles of the femora rufous at base, hind femora not more incrassate than in other species. *Wing*: Costa extending only a little way over  $R_{2+3}$ , and the two branches of the radial sector distinctly divergent. Posterior cross-vein obsolete on one wing, nearly complete on the other; distance between the two cross-veins equal to length of the posterior one. *Abdomen*: Dorsum of the first five abdominal tergites fuscous; posterior border of the fifth and the sixth completely dull orange; the seventh glossy-black, except on basal half on the sides where it is luteous. Sixth segment with six dorsal submarginal bristles, the two outside ones being larger than the median ones; there are also numerous small bristles on the dorsal and ventral surfaces of these segments. The seventh segment carries many small bristles on all its surface proximal to the pairs of long sub-apical bristles. Wing-length 2 mm.

Holotype: North Harbour, Sydney, 30th March, 1923, E. Ferguson. In coll. N.S.W. Dept. of Health, Sydney.

I have not seen the male which was described by Malloch (loc. cit., p. 92), who may have retained this specimen. This male was collected by Dr. Ferguson at Sydney on 2nd October, 1924. As it was not bred from a gall with the female, it is somewhat doubtful, in view of the numerous species of this genus, whether it belongs to the same species as the female redescribed above. The only characters which may allow their being linked together are those of coloration: all yellow, the ocelli ringed with black. The hypopygium of this specimen, as described by Malloch, is quite different from that of the other members of the genus since "its forceps are long, slender, heavily chitinized and directed forward below the venter" (1921).

16. *FERGUSONINA BISETA* Mall.

PROC. LINN. SOC. N.S.W., LVII, 1932, p. 215.

♂. *Head* yellow, the ocellar triangle not actually brown but the ocelli surrounded by brown. Antennae yellow, arista yellow on its basal third, distinctly pubescent, not at all distinctly incrassate at the base as is usually the case, thin on its whole length. Orbital, ocellar and post-vertical bristles rather small; smaller than the inner verticals. Vibrissae completely yellow, hairs of the face black, except those on the cheeks. *Thorax* rufous-yellow, mesonotum with a small vague fuscous marking just behind the humerus, postnotum yellowish. Three dorso-central and two pairs of prescutellar bristles, the median pair longer. Hairs on mesopleurae numerous, covering almost all its surface; bristles and hairs of sternopleurae all yellow. *Legs* with femora rather incrassate, all the longer bristles on front and hind femora extensively yellow at the base. *Wing*: All the veins yellow; costa reaching the middle of the distance between the two branches

of Rs, these two veins slightly divergent, the distance between the cross-veins equal to the posterior one. *Abdomen* entirely yellow; hypopygium (fig. 13) remarkable for the strong distal tooth on each side of the ninth tergite, lateral flaps with concave inner border; aedeagus with very small paraphalli which are provided with sensory setae. These and the penis are probably not so withdrawn basally as represented in figure 13 of the holotype and unique specimen. Wing-length 2.5 mm.

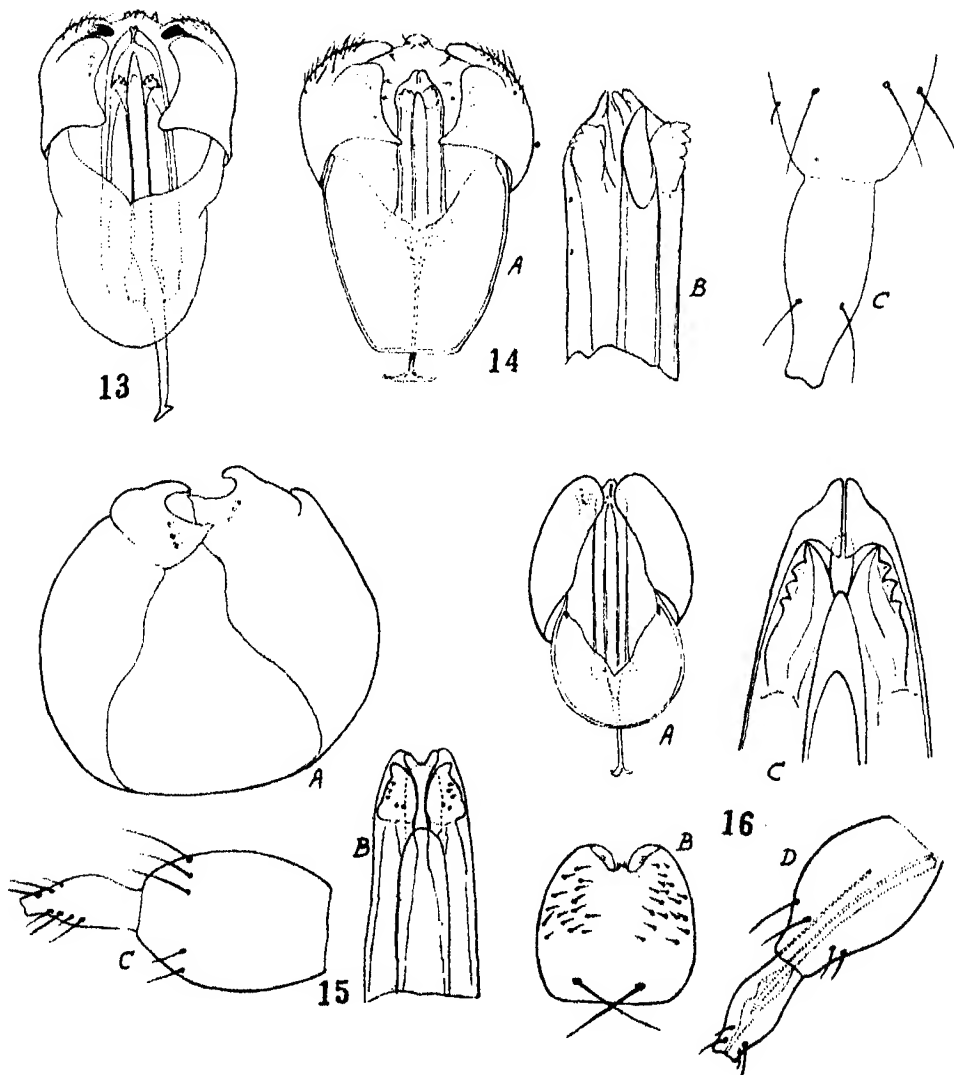


FIG. 13.—*Fergusonina biseta* Mall. Male hypopygium from below.

FIG. 14.—*Fergusonina nicholsont*, n. sp. A, male hypopygium from below; B, tip of intromittent organ,  $\frac{1}{2}$  view; C, ovipositor.

FIG. 15.—*Fergusonina curriei*, n. sp. A, ninth tergite from below, somewhat tilted back; B, tip of intromittent organ; C, ovipositor.

FIG. 16.—*Fergusonina tillyardi*, n. sp. A, male hypopygium from below; B, ninth tergite from above; C, tip of intromittent organ; D, ovipositor.

Holotype: Bodalla, N.S.W., October, 1929, bred from flower galls of *E. maculata*. In Coll. Department of Agriculture, N.S.W., Sydney. This specimen is rather teneral; when fully mature this species may have a more definite dark pattern on the mesonotum.

17. *FERGUSONINA NICHOLSONI*, n. sp.

♂. *Head* yellow, ocellar triangle orange, with a trace of brown in close proximity to the ocelli. Antennae yellow, basal third of arista orange, the rest infuscated, not flagelliform, distinctly pubescent; hairs of face and anterior part of frons paler, the vibrissae pale at base. The two upper orbital bristles are sub-equal. *Thorax* dull ochraceous-orange, mesonotum with a very small dark spot just above the neck, postnotum very faintly brownish. Only two dorso-central bristles; the prescutellar acrosticals not distinct. *Legs* yellow, all hairs and bristles black. *Wing* as in *F. pascotti*. *Abdomen*: Dorsum of first four tergites very slightly infuscated at base; the fifth with a small faint brownish median basal area. Hypopygium yellow, its latero-ventral flaps large, distinctly divided from the ninth tergite with an acute basal corner and three internal sensory setae (fig. 14A), intromittent organ as in figure 14B, which shows a three-quarter view of it; paraphalli with three lateral teeth and a very blunt apical one, no pores or sensory setae on them. Wing-length 2 mm.

♀. As in male, sixth abdominal segment completely pale, with four dorsal and four ventral submarginal bristles, the median pair of the latter smaller; seventh segment black, with only two pairs of bristles.

Holotype, allotype and a number of paratypes bred from flower-bud galls of *E. macrorrhyncha* by Dr. G. A. Currie, in December, 1932, at Canberra.

18. *FERGUSONINA CURRIE*, n. sp.

♂. *Head* yellow, ocellar triangle brown. Antennae completely yellow; basal fourth of arista yellowish, the rest infuscated, very thin and distinctly pubescent (at  $\times 24$ ). Vibrissae and hairs of face and of part of the frons pale. Two orbital bristles present, the anterior ones noticeably shorter, sometimes a very small bristle between the two. *Thorax*: Mesonotum dull orange-yellow with anterior dark markings just above the neck and short lateral fuscous vittae past the suture and rather faint median, dark, almost circular markings in centre of the disc. These two pairs of markings are sometimes obsolete. Scutellum and pleurae yellow, postnotum brown. Three pairs of dorso-central bristles and one pair of prescutellar acrosticals. *Legs* completely yellow, the large bristles of posterior femora partly yellow. *Wing*: Costa reaching a little over the tip of  $R_{4+5}$ ; branches of  $R_s$  sub-parallel, distance between the cross-veins a little longer than the posterior cross-vein. *Abdomen*: Dorsum of the first five segments dull, dark brown; this dark area interrupted by a yellow patch in the middle of segments one to three, fourth segment very narrowly margined with yellow, the fifth with a very wide margin. Hypopygium directed very much more downward and backward than usual, the whole of the aedeagus being bent almost at right angles in its middle; six flaps of ninth tergite well delimited from the capsule, and provided with a strong curved apical tooth (fig. 14A). Tip of intromittent organ as shown in figure 14B, the paraphalli with one blunt apical tooth, no lateral ones, and provided with five sensory pits, the three outer of these with setae. Wing-length 2.5 mm.

♀. Similar to male, dark markings of the mesonotum more often missing. Sixth abdominal segment dull brown except on posterior margin, the seventh

shining black; the sixth with three dorsal pairs of submarginal bristles and two ventral pairs; the seventh with three dorsal and four ventral pairs. Wing-length 3 mm.

Holotype, allotype and paratype bred from leaf-bud galls of *Eucalyptus macrorrhyncha* by G. A. Currie, 18th April, 1934, in Canberra.

#### 19. FERGUSONINA TILLYARDI, N. SP.

♂. *Head* lemon-yellow, ocellar triangle brown; hairs of face and anterior part of frons yellow, but the vibrissae completely black. Antennae yellowish, arista yellowish at the very base only, not elongate, its basal third incrassate, its distal part not flagelliform, sub-naked. Two large supra-orbital bristles sub-equal to the inner-vertexals. *Thorax* yellow, mesonotum orange-yellow with a black marking just above the neck; sometimes a slight brown vitta on the outside of the dorso-central bristles; in these darker specimens there is also a small round brownish spot on the middle of the disc and a faint streak on the mesopleurae: scutellum lemon-yellow, postnotum brown. The dorso-central bristles are long, especially the last ones, but the acrosticals are scarcely distinguishable from the other hairs of that region of the thorax. *Legs* yellow, all the hairs, including the bristles of the posterior femora, completely black. *Wing*: Venation as in *F. pescotti*. *Abdomen* yellow; base of dorsum of tergites two to five narrowly brownish, a dark area on each side of the first tergite; the band of the second tergite often interrupted in the middle. In the darker specimens the whole disc of the abdomen is blackish with very narrow, yellow margins to the tergites. Hypopygium yellow, its latero-ventral flaps not divided from the capsule of the ninth tergite, small and rounded and provided on the inside with three to four sensory setae (fig. 16A); tip of the intromittent organ as in figure 16C, paraphalli with one apical and three lateral teeth, no sensory pits. Wing-length 2 mm.

♀. Similar to male; darker specimens with lateral dark vittae on mesonotum and on mesopleurae are scarcer; these specimens have also the base of the dorsum of the sixth abdominal segment dark; usually this segment is completely yellow, it is provided with four large submarginal dorsal bristles and four smaller ventral ones. Wing-length 2.2 mm.

Holotype, allotype and numerous paratypes bred from flower-bud gall of *Eucalyptus Blakelyi* in Canberra by Dr. G. A. Currie, 19th December, 1933. Four specimens bred from galls of *E. camaldulensis* by Mr. J. W. Evans at Naracoorte, S.A., apparently belong to the same species; there are, however, no dark markings on the thorax, but the male genitalia correspond in every respect with those of the typical form.

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## GALLS ON EUCALYPTUS TREES.

A NEW TYPE OF ASSOCIATION BETWEEN FLIES AND NEMATODES.

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(Plates vi-vii; thirty-one Text-figures.)

[Read 23th July, 1937.]

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Introduction.

The flower buds of many *Eucalyptus* trees, particularly *Eucalyptus camaldulensis* Dehn. and *E. hemiphloia* F.v.M., are galled during certain seasons to such an extent that very few of them develop into normal flowers. Whole branches may break under the weight of galls. The trees named, and others, are the source from which much of the Australian honey is harvested, so galling restricts the honey output.

Galls of similar type were found affecting the flower buds of *Eucalyptus maculata* Hook., a valuable timber tree, so that the production of seeds was reduced. Morgan (1933) discovered that the organisms causing the galls on these trees were small nematodes and Agromyzid flies of the genus *Fergusonina*. Working independently, the writer had meanwhile been studying the galls on the flower buds of *E. macrorrhyncha* F.v.M. and found that they were caused by flies of the genus *Fergusonina* working in symbiotic association with small nematodes which were found to be closely allied to certain small plant-parasitic genera. Further work revealed that galls caused by the flies and nematodes, always associated, were common in all parts of Australia on many *Eucalyptus* trees. Galls were present on leaf buds, axil buds, stem-tips, and flower buds. In the photograph (Pl. vi, fig. 1), the difference between galled and ungalled flower-buds is clearly discernible, while the photograph of *E. macrorrhyncha* (Pl. vi, fig. 2) shows to what an extent galling may affect trees.

A review of literature on Australian galls disclosed that Rübsaamen (1894) had recorded dipterous larvae in flower-bud galls from Queensland. The species of tree is not stated, but the illustration resembles flower-bud galls found on *E. melanophloia* F.v.M. Cabbage (1918), writing on the flora of the Federal Capital Territory, records finding galls caused by the larvae of Agromyzid flies on flower buds of *E. dealbata* (probably this was *E. Blakelyi* Maiden), the galls being about 14 mm. in diameter, whereas the normal flower bud was only about 2 mm. wide. Bethune (1923), in the "Honey Flora of Victoria", refers to flower-bud galls on *E. camaldulensis*, but does not mention the cause.

Below are given the results of some five years' study of the gall-producing insects, the associated nematodes, and of the galls they produce.



*Life History of Fly and Nematode.*

There are many species of *Fergusonina* flies which attack *Eucalyptus* trees, and all are associated in the galls with nematodes. The fly which causes the galls on *E. macrorrhyncha* was studied most intensively, so the life history of that fly is presented here.

Adult flies emerge from the galls in summer, and the females, after mating, proceed to lay eggs in the young flower-buds which are appearing at that time. With each egg, any number of larval nematodes from one to fifty is passed into the cavity between the operculum and the floor of the inside of the bud. Many eggs may be laid in the same bud by a single fly or by several flies, and as many as 74 eggs and 227 nematode larvae have been found in a single bud.

Embryonic development within the egg of the fly proceeds during the next six weeks (eggs which were laid on 15th December hatched on 1st February). During that period the larval nematodes feed vigorously on the primordia of the stamens and cause a rapid proliferation of cells which form irregular masses inside the galled bud.

On hatching, the fly larvae make their way between two contiguous masses of cells and tear out small crypts in which to lie. The larval nematodes join them in their several crypts and develop rapidly to the adult stage. The nematodes of that generation are all parthenogenetic females which lay eggs in the gall cavity alongside the fly larva, with which they lie in contact. The fly larva passes through three instars, all in the crypt inside the galled bud, obtaining its food from the plant cells surrounding it. During the first and second instars it feeds on the gelatinous cell-sap, some of which oozes from the cells after they have been punctured by the stylets of the nematodes. The third instar larva tears down the walls of the cavity in which it lies and feeds on the ruptured cells.

The nematodes breed parthenogenetically in the cavity during the larval life of the fly without harming it in any way, males appear in numbers in the autumn and winter, and when the female fly larva is about to pupate, two fertilized female nematodes enter its body cavity, probably through the skin. There, during the pupal period of the fly, the female nematodes change from the free-living form to a much enlarged parasitic form which has no stylet or gut, the whole of its internal space being filled by a much enlarged ovary. Male flies are never parasitized in this way by the nematodes, female flies invariably so. By the time the female fly emerges adult the parasitic nematodes are discharging large numbers of segmenting eggs inside its body cavity. On hatching, larval nematodes make their way to the ovary, penetrate into the oviduct, and there await the passage of an egg down the chitinous ovipositor, whence they accompany it into the young flower-bud to start the cycle anew.

This life history can be taken in its broad outlines as typical for the whole series of flies. The time of year when adults emerge and the point of the tree attacked vary, but young growing tissue is always selected by the flies for oviposition, and the nematode larvae which are always deposited with the eggs of the fly are active before the eggs hatch.

*Methods.*

*Larvae of flies.*—Larvae of different ages were dissected alive from the galls and the natural outlines drawn with the camera lucida. For detailed study of skin structures and mouth parts, larvae were boiled in caustic potash, then the

skins were washed, cleared in glacial acetic acid, stained with acid fuchsin and mounted in Canada balsam.

*The adults.*—Female flies bred out in the laboratory were dissected daily in saline to study the development of the ovaries and of the parasitic nematodes. Others were placed in organdi sleeves enclosing young flower-buds so that oviposition could be observed and buds labelled with the date on which eggs had been laid in them.

*The nematodes.*—Minute studies of the internal organization of the free-living nematodes were made on fresh material just immobilized by heat. A small cell on a glass slide was found to answer well for this purpose. Parasitic females had to be studied in normal saline; in water they rapidly swell up and burst. Semi-permanent mounts were made with glycerine.

*The galls.*—Fresh galled buds were collected and studied throughout the years and much information was obtained in this way. Some sections of the galls were kept for permanent record, but no wholly satisfactory technique was discovered to fix and preserve equally well the vegetable tissues, the nematodes and the fly larvae. Alcoholic Bouin penetrated rapidly in vacuo and the material stained, dehydrated, cleared, and mounted in hard paraffin gave some reasonably good sections.

#### ELEMENTS IN THE ASSOCIATION.

##### 1. *The Fly.*

The adult flies bred out from galls during the investigation have been described by my colleague, Mr. A. L. Tonnoir (1937), who has revised the genus *Fergusonina*. Malloch named the genus for the noted Australian dipterist, Dr. Ferguson, and classified it in the family Agromyzidae; the genus is somewhat aberrant, however, and Tonnoir has decided to place it in a subfamily by itself. All the flies are small, with a wing span ranging from 5 mm. to about 7 mm., and are of a mottled yellow and black colour. The females have strong ovipositors similar to those of the Trypetidae (Pl. vii, fig. 1). They were found to be rather weak fliers and did not readily take wing.

In warm weather mating takes place about 48 hours after emergence, but is delayed in cold weather; the adult flies live in the summer months from about 6 to 20 days only. They have not been seen feeding in the open, but in captivity they suck up water or sugar syrup readily. Egg-laying generally takes place during the hours from 10 a.m. to 2 p.m. The females appear to lay equally in shade or in the sun during warm weather, but during cool weather the ovipositing females congregate on the sunny side of the trees. Owing to this habit it was observed that, when the weather was colder than usual during the period when flies were most common, the northern side of the trees was more heavily galled than the southern; when temperatures were fairly high, however, most of the buds on the tree were galled. When the galls mature, and just for a few weeks afterwards, the flies are extremely common, and the fact that they have not been taken and described more frequently than has been the case in the past is probably due to four factors: (1) Their small size; (2) their short life as adults; (3) their habit of clinging closely to the branches and not flying readily; (4) that little attention has been given by collectors in Australia to the small diptera.

##### *Emergence of Adult Flies from Galls.*

A considerable number of different methods for the emergence of the adult flies from the galls have been developed by the different species of flies.

*F. nicholsoni*, which has been discussed earlier, emerges when the operculum of the galled flower-bud lifts. When the flower-bud galls of *E. Blakelyi* are fully mature the inner portions dry up and break up into a powder, through which the adult flies (*F. tillyardi*) escape to the exterior; the galls frequently drop to the ground at maturity and the flies escape from them there. The larvae of *F. curriet* living in the community leaf-bud galls of *E. macrorrhyncha* burrow when full fed to a point just under the skin of the gall and there pupate; the adult fly can then push its way readily to the exterior. The larva of *F. gravesi* cuts a round hole in the wall of the gall chamber before it pupates, leaving only the epidermis unbroken; through this the fly escapes at emergence. This last method of emergence is commonly used by the various larvae inhabiting leaf and stem-tip galls.

The puparia which inhabit the leaf, axil bud, and stem-tip galls are all found attached to the wall of the galls by a transparent elastic jelly fixed to the anal end. This gelatinous material, which is voided by the full-fed larva just before pupation, holds the puparium in position at the anal end while the adult fly bursts its way through the anterior end. This substance is absent from most of the puparia found in the flower-bud galls.

*Description of immature stages of FERGUSONINA NICHOLSONI Tonn.*

This species from flower-bud galls on *E. macrorrhyncha* is taken as a type to illustrate the stages in the life history of flies of the genus *Fergusonina*.

**Egg.**—The egg is a spindle-shaped, transparent, glistening body. It tapers to a sharp point at one end and to a more rounded tip covered by a cap at the micropylar end (Fig. 1). Length of egg, 0.33 to 0.4 mm.; width of broadest part, 0.1 mm.

**First instar larva** (Fig. 2).—At hatching the larva is shorter than the egg from which it hatches. The mouth parts are 0.04 mm. long at this stage. No signs of spiracles or tracheae have been observed in this instar. Rows of papillae are clearly distinguishable along the line of junction of segments on the dorsal surface. Length, 0.23 mm.; width, 0.07 mm.

**Second instar larva** (Fig. 3).—This larva is immobile and lives in a small close-fitting cavity surrounded by nematodes bathed in a mucilaginous fluid apparently exuded by the cells lining the gall cavity. Its skin is extremely delicate and transparent, all the internal organs are easily distinguishable, and the papillae marking the junction of the segments of the dorsum are very pronounced. The mouth parts are minute in proportion to the bulk of the larva and do not appear to be used for tearing, the larva imbibing the fluid in which it lies. The actual size of the mouth parts is less than that of the first instar, a contradiction to the normal rule, the length being only 0.024 mm. No sign of a tracheal system can be distinguished in this instar. Length, 0.9 mm.; width, 0.7 mm.

**Third instar larva** (Fig. 4).—From the delicate 2nd instar larva the 3rd instar emerges as a vigorous, tough-skinned larva, with strong mouth-parts and heavily-chitinized spiracles opening into a well-defined tracheal system. The respiratory system is amphipneustic. The mouth parts are 0.133 mm. long. On the dorsal surface is a strongly-chitinized dark-brown plate not present on the first and second instars which, for the sake of convenience, one may call the "dorsal shield", extending from the first thoracic segment over the first and second abdominal segments. The general shape of the larva is sub-ovate, but

many other species of *Fergusonina* have pyriform larvae. Length, 1.3 mm.; width, 0.9 mm.

*Structure of spiracles and mouth parts of Fergusonina larvae.*

The spiracles are fairly similar in shape throughout the series of larvae discovered so far. The three slits of the spiracles are raised on protruding lips resembling the corolla of a flower (Fig. 22). The anterior slit of the anterior spiracles is nearly as big as the other two slits combined. Small elliptical perforations through the slits allow air to enter the felt chamber, which is walled with brown chitin, and this in turn leads into a large trachea. The posterior spiracles are remarkably similar to the anterior, both in size and shape.

Figure 22 illustrates, by camera lucida drawings, the spiracle of 3rd instar larvae from leaf galls on *E. maculosa* and the spiracle of 3rd instar larvae of *F. tilyardi*. Such differences as can be observed between these two represent the amount of difference to be seen between the most dissimilar pair of the series of larvae.

The larvae from the flower-bud galls of *E. pauciflora* have smaller spiracles than the others, and the chitin forming them is not so deeply pigmented, but otherwise the structures are very similar.

The mouth parts (bucco-pharyngeal apparatus) are fairly regular in shape throughout the series. Two sets are illustrated in Figures 23 and 24. Figure 23 is a drawing of the mouth parts of *F. tilyardi* Tonn., and Figures 24 and 25 of those of *F. eucalypti* Mall. These two sets have been chosen because they show as great a difference between them as can be found between any two species of the genus.

*The Puparium.*

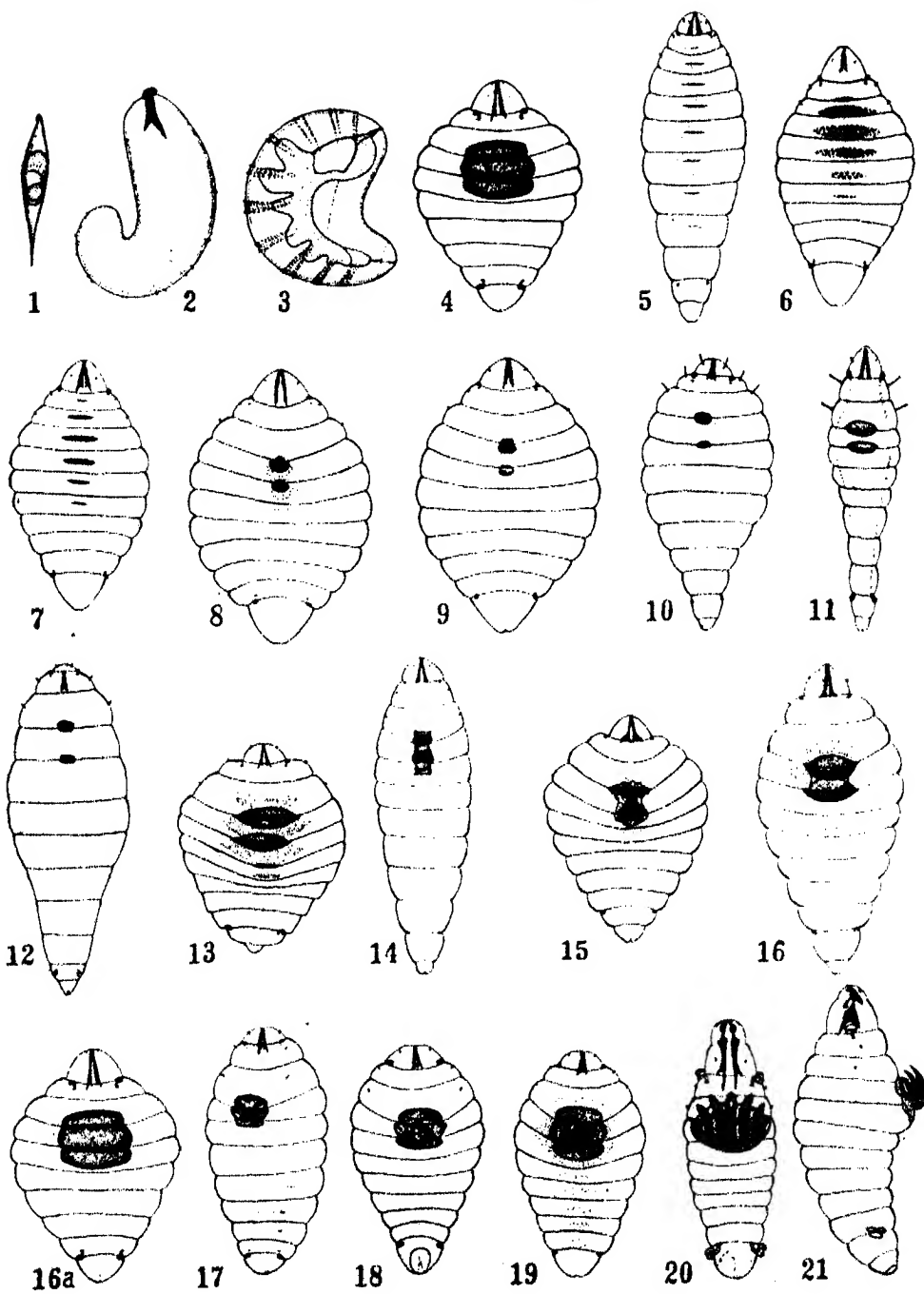
The puparium lies in the eaten-out cavity of the gall until the emergence of the adult fly. In form it is the typical barrel-shaped dipterous puparium of the Cyclorrhapha, with no distinctive characters, and varies in colour from light straw on pupation to dark brown just before emergence of the fly.

*Description of 3rd Instar larvae of Fergusonina species with special reference to the dorsal "shield".*

The mouth parts of spiracles did not appear to have diagnostic value, but the dorsal shield on the various larvae proved to be a useful diagnostic feature. The sequence in which the third instar larvae are described indicates the possible direction of the evolution of this organ.

The dorsal shield, which is considered to be the most primitive of those discovered, consists merely of scattered spots of chitin on the terga of the 2nd and 3rd thoracic and 1st, 2nd, 3rd, 4th, 5th, and 6th abdominal segments. A series of shields of increasing complexity then follows, culminating in one which consists of a black plate from which a strong rake-like organ, carrying from 5 to 7 teeth, projects outwards.

1. *Fergusonina* sp. 1 (Fig. 5).—From stem-tip gall on *E. pauciflora*, Mount Kosciusko, N.S.W., June, 1935; galls collected by M. J. Mackerras. This larva carries small spots of chitin over the greater part of the dorsum. Long narrow patches, composed of closely-set spots of chitin, are present on the 2nd and 3rd thoracic and the 1st to the 6th abdominal segments. These patches are on the most projecting parts of the convex segments, so that they come into contact frequently with the walls of the gall in which the larvae live. Paired papillae are present on each of the three thoracic segments, two pairs on the first and one pair each on the other two segments. The spiracles are prominent, and open



into the amphipneustic respiratory system. The adult has not yet been described. Length of full-grown larva, 5 mm. approx.; width of full-grown larva, 1.6 mm. approx.

2. *Fergusonina* sp. 2 (Fig. 6).—From stem-tip on *E. macrorrhyncha*, Black Mountain, F.C.T., Sept., 1934; collected by the author. This 3rd instar larva carried a dorsal shield formed of scattered spots of chitin on the dorsum. There are chitinous cones on the 2nd and 3rd thoracic and on the 1st, 2nd, 3rd and 4th abdominal segments, each cone being surrounded at its base by smaller spots of chitin. Paired papillae are present, as in the species just described, and the spiracles are very similar. Length of full-grown larva, 1.7 mm. approx.; width of full-grown larva, 1.0 mm. approx.

3. *Fergusonina curriei* Tonn. (Fig. 7).—From leaf galls on *E. macrorrhyncha* (see photo, Pl. vi, fig. 5), Canberra, F.C.T., Oct., 1933; collected by the author. In this larva the dorsal shield is present on the same six tergites as in the former species, and sometimes extends to the fifth abdominal segment. The chitinized spots are somewhat irregular and coalesce on each segment to form a more or less coherent plate; this distinguishes it from the species previously described. The papillae on the thoracic segments are somewhat smaller than those of the preceding species, and the larva is much larger. Length of full-grown larva, 3.7 mm.; width of full-grown larva, 2.3 mm.

4. *Fergusonina* sp. 3 (Fig. 8).—From leaf galls on *E. sideroxylon*, *E. maculosa*, *E. melliodora* and *E. macrorrhyncha* in Victoria and in New South Wales, 1933-34. In this species the dorsal shield represents a further step in specialization. Coherent chitinized patches are found in two places, the anterior at the junction of the third thoracic segment with the first abdominal, and the posterior, at the junction between the second and third abdominal segments. Chitinous spots are scattered round both areas. The adult of this species has not yet been bred out and, as the larva is not very different from others which follow, it is not considered desirable to name it at present. Length of full-grown larva, 2 mm.; width of full-grown larva, 1.4 mm.

5. *Fergusonina* sp. 4 (Fig. 9).—From leaf galls on *E. maculosa*, Black Mountain, Canberra, F.C.T., July, 1934; collected by the author. This larva is very like the preceding, but has a regular slight difference in the shape of the dorsal plates, and has fewer spots around the shield. It may be a variety of the preceding species, but the adults have yet to be bred to give evidence on this point. Length of full-grown larva, 2.3 mm.; width of full-grown larva, 1.4 mm.

6. *Fergusonina evansi* Tonn. (Fig. 10).—From leaf galls on an unidentified *Eucalyptus* tree in Adelaide, South Australia, August, 1933; collected by J. W. Evans; and from leaf galls on *E. melliodora* at Canberra, October, 1934, by the author. The dorsal shield differs somewhat in shape from the foregoing species, and the papillae on the thoracic segments are elongated, apparently in adaptation to the comparatively large gall-cavity in which the larva lives. Length of full-grown larva, 2.7 mm.; width of full-grown larva, 1.5 mm.

#### Text-figures 1-21.

1-4.—*Fergusonina nicholsoni* Tonn. 1, egg,  $\times 50$ ; 2, first instar larva,  $\times 50$ ; 3, second instar larva,  $\times 45$ ; 4, third instar larva,  $\times 25$ .

5-21.—Third instar larvae of *Fergusonina* species.

5, *Fergusonina* sp. 1,  $\times 8$ ; 6, *F. sp. 2*,  $\times 18$ ; 7, *F. curriei* Tonn.,  $\times 8$ ; 8, *F. sp. 4*,  $\times 18$ ; 9, *F. sp. 5*,  $\times 18$ ; 10, *F. evansi* Tonn.,  $\times 12$ ; 11, *F. carteri* Tonn.,  $\times 28$ ; 12, *F. greavesi*, n. sp.,  $\times 8$ ; 13, *F. eucalypti* Mall.,  $\times 12$ ; 14, *F. sp. 10*,  $\times 8$ ; 15, *F. sp. 11*,  $\times 10$ ; 16, *F. sp. 12*,  $\times 16$ ; 17, *F. newmani* Tonn.,  $\times 16$ ; 18, *F. brimblecombei* Tonn.,  $\times 22$ ; 19, *F. lockharti* Tonn.,  $\times 12$ ; 20, *F. tilyardi* Tonn.,  $\times 22$ ; 21, *F. tilyardi* Tonn.,  $\times 14$ .

Fig. 16a is a repetition of Fig. 4 in its place in the series.

7. *Fergusonina carteri* Tonn. (Fig. 11).—From leaf galls on *E. Stuartiana* F.v.M., Canberra, F.C.T., November, 1933; collected by the author. The dorsal plates are clearly defined in the larvae of this species and not surrounded by spots of chitin. The papillae are very large, the larvae living in gall cavities which are large relative to the size of the larvae. Length of full-grown larva, 1.2 mm.; width of full-grown larva, 0.4 mm.

8. *FERGUSONINA GREAVESI*, n. sp. (Fig. 12).—From stem-tip galls on *E. polyanthemus* Schau., Black Mountain, Canberra, July, 1934; collected by the author. The 3rd instar larva of this species is comparatively large, found rather rarely in stem-tip galls of *E. polyanthemus* Schau. The adult fly has not been reared, but the larva is so distinct in size, and in the character of the dorsal shield, that it is felt that the species may be described from the larva without danger of creating difficulties for later workers. It is anticipated, moreover, that the adult flies of this species will be bred out from the galls by the author at some later date, and can then be described in association with the larvae, so that no confusion of identification may arise. The full-grown larva is smooth, clearly segmented, yellowish, with four chitinous plates, in two pairs, on the dorsal surface. One pair is in contact at the junction of 3rd thoracic segment with the 1st abdominal, the other pair is in contact at junction of 1st with the 2nd abdominal segments.

Size of plates approximately: (1) Plate on 3rd thoracic segment, width 0.25 mm., depth (i.e., anterior to posterior margin) 0.12 mm.; (2) Anterior plate on 1st abdominal segment, width 0.2 mm., depth 0.033 mm.; (3) Posterior plate on 1st abdominal segment, width 0.2 mm., depth 0.075 mm.; (4) Anterior plate on 2nd abdominal segment, width 0.25 mm., depth 0.06 mm. Length of full-grown larva, 4.3 mm.; width at widest part, 1.8 mm.

Holotype and paratype on slides in museum of Division of Economic Entomology, C.S.I.R., Canberra, F.C.T., Australia.

9. *Fergusonina eucalypti* Mall. (Fig. 13).—From flower-bud galls of *E. maculata* Hook., Bateman's Bay, N.S.W., September, 1930; collected by W. L. Morgan. In the 3rd instar larva of this species the chitinous dorsal shield is made up of four plates, relatively much larger than those of the foregoing species, and a fifth smaller plate situated at the posterior margin of the 2nd abdominal segment. Rows of chitinized spots surround the plates extending on to the 3rd and 4th abdominal segments. The thoracic tubercles are short, the larvae inhabiting gall cavities into which they fit fairly tightly. Length of full-grown larva, 3 mm.; width of full-grown larva, 1.8 mm.

10. *Fergusonina* sp. 5 (Fig. 14).—From flower-bud galls on *E. pauciflora*, Mount Kosciusko, N.S.W., June, 1935; collected by M. J. Mackerras. The dorsal shield is a more complicated structure than any of those described already. There is a thin sheet of chitin on the 3rd thoracic segment, which thickens towards the point of junction with the 1st abdominal segment and forms a concave plate there. At the anterior edge of the 1st abdominal segment a convex chitinous hump covered with small protuberances is hinged to the chitinous concave plate described above. Any curling movement of the larva caused the convex portion to fit into the concave, but the function is unknown. The concave plate is repeated at the posterior portion of the 1st abdominal segment, and into it fits a convex portion from the anterior edge of the 2nd abdominal. Both sets are loosely connected by thin plates of chitin which have a reticulated structure. The spiracles of this larva are neither so prominent nor so complicated in their structure as any of the other larvae described. Length of full-grown larva, 4.3 mm. approx.; width of full-grown larva, 1.5 mm. approx.

11. *Fergusonina* sp. 6 (Fig. 15).—From axil-bud galls (Fig. 31) on *E. maculata*, Bateman's Bay, N.S.W., July, 1934; galls collected by Dr. Jacobs. The adult fly has not yet been reared. The larva is pearly-white with a well-defined dorsal shield. This shield is formed of four small dense plates of chitin in pairs, as in the species just described, but easily distinguished from them by the irregular area of full-coalesced chitinous spots surrounding the plates. Outside this area of less dense coalesced spots of chitin are isolated spots of chitin on the 2nd and 3rd abdominal segments. This structure presents a possible transitional stage between the separated plates of *F. eucalypti* Mall. and the coherent shield made up of plates all fused together in *F. nicholsoni* Tonn. The dorsal shield, measured at the widest point of the irregularly fused chitin, is about one-fourth the width of the larva at its widest point, and is about the same length as it is wide. Length of full-grown larva, 2.8 mm.; width of full-grown larva, 1.6 mm.

12. *Fergusonina* sp. 7 (Fig. 16).—From the leaf and leaf-stem galls on *E. Stuartiana*, Black Mountain, Canberra, F.C.T., March, 1935; collected by the author. The dorsal shield of this larva is composed of four loosely-joined plates which give the effect of a single plate. There are rows of strong black spines surrounding the shield on the 1st, 2nd, 3rd and 4th abdominal segments and on the 3rd thoracic segment, all the spines pointing inwards towards the shield. The shield measures approximately 0.4 mm. in width and 0.4 mm. in length. There is an extra plate on some specimens on the 3rd abdominal segment near its anterior margin. Length of full-grown larva, 2.1 to 2.3 mm. approx.; width of full-grown larva, 1.2 mm. approx.

The galls which this species inhabits are quite different from leaf galls on the same tree harbouring *F. carteri*.

13. *Fergusonina nicholsoni* Tonn. (Figs. 4 and 16A).—From flower-bud galls on *E. macrorrhyncha*, Canberra, F.C.T., November, 1930; collected by the author. The 3rd instar larva of this species has been described in some detail earlier in this paper, but it fits here into its place in the evolutionary series based on the complexity of the dorsal shield. All the plates which, in species described earlier, were separate, are fused in this larva to form a coherent shield. This shield is set on the top of a hump formed by the slightly protruding dorsal segments. The thoracic tubercles are not developed in this larva, as it lives in a cavity into which it fits tightly. Length of full-grown larva, 1.3 mm.; width of full-grown larva, 0.9 mm.

14. *Fergusonina newmani* Tonn. (Fig. 17).—From leaf-bud galls on *E. gomphocephala* DC., Perth, Western Australia, August, 1933; collected by the author. The 3rd instar larva of this species has the chitinous shield developed as in the foregoing species, but in addition, rising from the point of junction of the 1st and 2nd abdominal segments on the shield, there are two strong black hooks. These hooks appear to be used for tearing down the walls of the gall chamber for food, and their number may vary from two to three in this species of larva. The thoracic tubercles are longer than they are on the two species last described. Length of full-grown larva, 1.9 mm.; width of full-grown larva, 1.0 mm.

15. *Fergusonina brimblecombei* Tonn. (Fig. 18).—From flower-bud galls of *E. crebra*, Queensland; *E. melanophloia*, Queensland; *E. odorata*, South Australia; and *E. hemiphloia*, Victoria, June and July, 1934; collected by A. Brimblecombe, J. W. Evans and W. W. Morgan. In the 3rd instar larva of *F. brimblecombei* Tonn. the chitinous shield is similar in shape to that of the preceding species, but in addition to two hooks, which are also present in this larva, there is a strong



scoop-like projection rising from near the base of the hooks. This projection rises to about one-third of the height of the hooks. Small tubercles are present on the thoracic segments. Length of full-grown larva, 1.3 mm.; width of full-grown larva, 0.8 mm.

16. *Fergusonina lockharti* Tonn. (Fig. 19).—From globular, irregular, stem-tip galls on *E. rudis* Endl., Mundaring, Western Australia, August, 1933; collected by the author. In the 3rd instar larva of *F. lockharti* Tonn. the dorsal shield is relatively larger than that of the preceding species and the hooks which rise from the shield near the posterior margin of the 1st abdominal segment are shorter and stouter. There are three to five hooks in this larva, the usual number (as illustrated) being four. Length of full-grown larva, 2.2 mm.; width of full-grown larva, 1.2 mm.

17. *Fergusonina tillyardi* Tonn. (Figs. 20, 21).—From flower-bud galls on *E. Blakelyi*, Canberra, F.C.T., *E. cumaldulensis*, Victoria and South Australia, and *E. tereticornis*, Victoria. The 3rd instar larva of *F. tillyardi* Tonn. has the most complex dorsal shield of the whole series. From the strong dorsal plate rises a rake formed of hooks, the number of these varying from five to seven. The relative size of the structure can be seen from the illustration. Figure 20 shows the larva newly moulted into the 3rd instar, so that the proportions of the mechanism relative to the body are exaggerated. Figure 21 shows a side view of a larva nearly full grown, so that the disproportion is not so great. Length of full-grown larva, 2.6 mm.; width of full-grown larva, 0.85 mm.

#### *Function and Evolution of Dorsal Shield.*

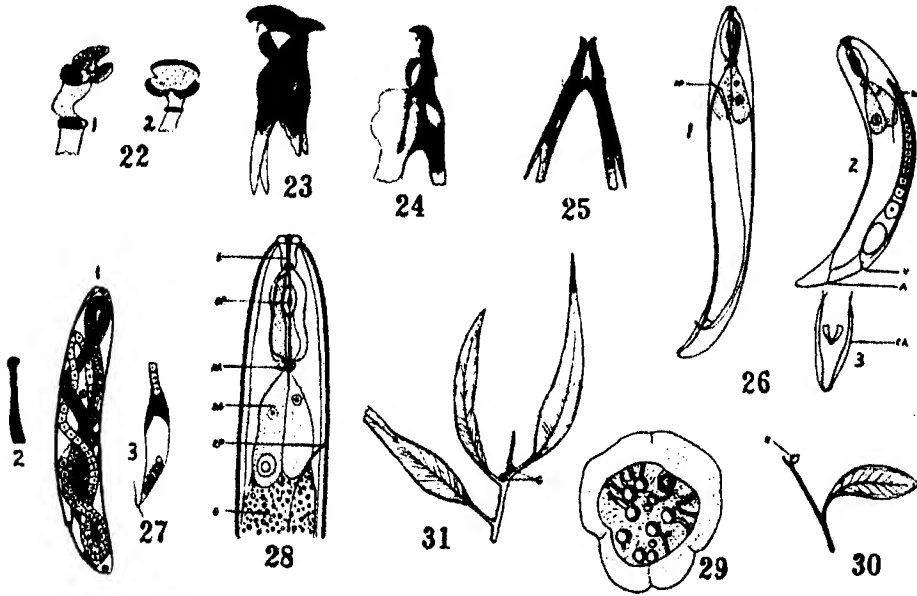
The first and second instar larvae, which feed on the contents of the soft cells lining the inner wall of the gall cavity, do not carry a dorsal shield, nor is such a shield known from any related dipterous larvae. Observation of the third instar larvae shows clearly that those larvae which possess hooks on the shield use them to tear down the walls of the galls, which begin to harden at this stage, for food. The function of this chitinous armature on the types which are not armed with hooks is unknown. The author has observed, however, that the 3rd instar larvae described above in *Fergusonina* sp. 7, from the leaf-stem galls of *E. Stuartiana*, void their faeces continually on to the dorsal shield. The nematodes are found concentrated there and apparently feeding on the faeces, but, owing to the quantity, not able to keep pace with the supply.

Faeces are practically absent in the galls made by other species of the same genus of flies, so the assumption is that the nematodes remove them as they are produced. The voiding of the faeces on the dorsum, and the feeding of the nematodes there, may be connected in some way with the presence of the chitinous patches forming the shield. When a larva bends its head backwards the axis of the body is the 1st abdominal segment and the parts just in front and behind this. This is the area which carries the dorsal shield, so that although the association between the defaecation on the dorsum, the nematodes feeding, and the presence of the chitinous shield is conjectural, it is at the same time highly suggestive.

Shields ranging from the scattered conical projections found on *F. currici* Tonn., through the various stages of increasing complexity to the highly specialized rake carried on the dorsum of *F. tillyardi* Tonn., form a linear series which may indicate the direction of evolutionary development. In general, the types of galls formed by the more advanced larvae (as judged by the complexity of the dorsal shield) are of a more complex nature than those of the more primitive types. The relationship with the nematodes, which are found always associated with the

larvae, and which, in all cases so far studied, are transmitted by the adult female flies from one gall to the next, is also more highly adjusted in most of the species having the more advanced type of dorsal shield than in those carrying the simpler shields.

The simpler types of shield are found on larvae inhabiting leaf, stem, and stem-tip galls, while the more complicated shields are found mainly on larvae which inhabit galls on the flower buds. Purely as a matter of conjecture based on observations of these larvae, it seems that the primitive ancestor of these forms was a tunneller in the vegetative parts of the *Eucalyptus* trees. Scattered spots of chitin were replaced in some species by more and more coherent plates of chitin situated at the points of junction of the last thoracic and the first abdominal segments and of the 1st and 2nd abdominal segments. Having developed into a coherent shield, the next step forward to the development of the rake on the shield is more easy to interpret on the basis of function.



Text-figures 22-31.

22.—Anterior spiracle of larvae of *Fergusonina* spp. (1, *Fergusonina* No. 4; 2, *F. tillyardi* Tonn.),  $\times 100$ .

23.—Mouth parts of *F. tillyardi* Tonn.,  $\times 60$ .

24, 25.—Mouth parts of *F. eucalypti* Mall. (24,  $\times 60$ ; 25, dorsal view,  $\times 60$ ).

26.—*Anguillulina (Fergusobia) tumifaciens* (1, male; 2, free-living female; 3, male, ventral view of anal end.  $\times 100$ ). V, vulva; A, anus; E.P., excretory pore; C.A., caudal alae.

27.—Parasitic female (1, side view; 2, tip of ovary; 3, oviduct expanded forming a receptaculum seminales. Mature eggs ready to be laid lying in uterus.  $\times 40$ ).

28.—Anterior end of free-living female of *A. tumifaciens*.  $\times 270$ . S, stylet; O.P., oesophageal pump; N.R., nerve ring; E.P., excretory pore; D.G., dorsal gland; G, gut.

29.—Cross-section of galled flower-bud of *E. macrorrhyncha*. Semi-diagrammatic, showing stalked gall-jets inside the galled flower bud.  $\times 2$ .

30.—Gall on *E. polyanthemus*. E, point at which fly will emerge.  $\times 0.2$ .

31.—Axil bud galls on *E. maculata*. G, galls.  $\times 0.2$ .

The great variety of *Eucalyptus* species provided opportunity for variation in the flies. Adaptation to galls which harden and dry out fairly rapidly at maturity would be successfully attained by species which developed a mechanism to tear down the hardening tissues for food. Forms carrying hooks would survive more readily than others not so well equipped.

It is necessary here to point out that the degree of adaptation of the larva to a special environment need not be, and indeed is not, reflected in the adult fly which has to meet a totally different set of conditions. Tonnoir, in describing the adult flies, could not find any characters which would suggest that the flies from the more primitive types of larvae were more primitive in structure than those from the more highly adapted larvae. The larval environment induces reaction in structure which have no apparent counterpart in the structure of the adult fly.

## II. *The Associated Nematode.*

The nematodes described below were taken from leaf galls of *E. Stuartiana* in which they were found associated with *F. carteri* Tonn. They were chosen because large numbers of them were available at a time when it was convenient to study them in the laboratory. The parasitic female nematodes were derived from the body cavities of females of *F. carteri* Tonn.

### ANGUILLULINA (FERGUSOBIA) TUMIFACIENS, n. subgen. et sp.

*The egg* (Pl. vii, fig. 4).—There is no apparent difference between the eggs laid by the free-living females in the gall and the parasitic females inside the *Fergusonina* flies. The eggs of both types of females are already segmenting when laid and, prior to hatching, the larva can readily be seen moving round inside the shell. The outer skin of the egg is tough and translucent, without sculptural markings, and its shape is nearly cylindrical with both ends rounded. Length of egg, 0.05 to 0.055 mm.; width of egg, 0.018 to 0.025 mm.

*The larva* (Pl. vii, fig. 4).—The newly-hatched larva measures 0.14 to 0.19 mm. long and 0.009 to 0.011 wide. It has a well-developed stylet carrying three basal swellings and measuring 0.006 mm. in length. The number of larval instars has not been determined accurately, but at least four instars are discernible.

*The adult*.—The free-living form (actually a plant-parasite in the leaf galls of *E. Stuartiana*) may be treated as the normal form and will be described first.

#### (a). Male (Fig. 26, 1).

Principal measurements: Length, 0.415 mm.; width, 0.049 to 0.05 mm.; anterior end to end of oesophageal region, 0.124 mm.; anterior end to excretory pore, 0.089 mm.; anus to tip of tail, 0.04 mm.; length of buccal stylet, 0.012 mm.; length of spicules, 0.021 mm.; proportions: length to breadth, 8.9:1; length to length of oesophagus, 3.4:1; length to length of tail, 10.12:1.

The cuticle is finely striated transversely. The head is separated from the body by a very slight constriction, has rounded sides, and shows no sign of separate lips or papillae. The body tapers slightly towards the head from the posterior end of the oesophageal region, but tapers much more abruptly towards the tail. The oesophageal region is well defined. The dorsal pharyngeal cell is very prominent, with a large nucleus, and opens by a short duct just behind the stylet. No gubernaculum has been seen in any specimen examined. The paired spicules are in contact distally, but are separated at their proximal extremities. They show a distinct elbow bend when viewed laterally and taper to a rounded point. The gonad is unpaired and in mature specimens it can be seen lying with

its origin in the oesophageal region, thence running backwards without reflexing to open in the cloaca. The tail tapers to a rounded point. The cuticle is expanded laterally to form two alae arising well in front of the cloaca and extending round the tail tip (Fig. 26). The margins of the alae are slightly crenate.

**Spermatozoa:** Under high magnification the globular spermatozoa were observed to possess a number of processes which looked like amoeboid strands with their distal portions slightly clubbed. When stains were applied the globular portion took up the stain, but the strands did not do so, or did so to a less extent.

(b). Free-living female (Fig. 26, 2).

**Principal measurements:** Length of body, 0.415 mm.; width of body, 0.056 mm.; length, anterior end to end of oesophageal region, 0.123 mm.; length, anterior end to excretory pore, 0.09 mm.; anus to tip of tail, 0.039 mm.; vulva to tip of tail, 0.08 mm.; buccal stylet, 0.019 mm.; proportions: length to breadth, 7.8:1; length to length of oesophagus, 3.4:1; length to length of tail, 10.1:1.

The female is more bluntly rounded anteriorly than the male, but tapers more rapidly posteriorly. The head and oesophagus are similar to those of the male. The single ovary arises near the nerve ring and opens into an oviduct in which there is no post-vulval pouch. One to three fully developed eggs may lie in the oviduct. The lips of the vulva are prominent in mature females but not in immature specimens.

(c). Parasitic female (Fig. 27).

**Principal measurements:** Length of mature female, 0.69 to 0.87 mm.; width of mature female, 0.12 to 0.14 mm.; length of ovary removed from body and stretched out straight, 3.0 mm.; vulva to posterior tip of body, 0.15 to 0.22 mm.

When the fertilized female enters the haemocoel of the fly larva, she carries the stylet and oesophagus of the free-living form. Growth is rapid, however, the female soon loses the stylet, and the gut shrinks as the rapidly expanding, much coiled, ovary grows to fill almost entirely the whole space inside the skin. Just under the cuticle in this stage a layer of polygonal pavement cells can be seen, which, according to Goodey (1930), allow a great increase in size without further moulting.

Some of the parasitic females could flex their bodies until head and tail nearly met, while in others the power of movement had been lost entirely. Those from the body of *F. nicholsoni* retained the power of movement only up to the stage at which egg-laying commenced; after that, movements of the body as a whole ceased.

#### *Development of the Parasitic Nematode in the Flies.*

The parasitic female nematodes live in the haemocoel of the larval, pupal, and adult female flies. On entering the female fly larvae the nematode still possesses all the free-living characters, including the stylet (Pl. vii, fig. 7). About the time at which the fly larva pupates the nematodes grow rapidly, lose their stylet, and develop a great reserve of food, before their ovaries become apparent (Pl. vii, fig. 10). At the stage when the fly larva has pupated, the nematode female can be seen lying in the finely disintegrated fat-body of the insect with multitudes of the small particles of the fat-body so firmly adherent to the outside of the skin that it requires some force to remove them. At this stage the ovary of the nematode develops and becomes differentiated at a very rapid rate, while the ovary of the fly is only beginning to develop. It looks as if the same factors which lead to the growth of the fly ovary have caused a parallel rapid develop-

ment in the nematode ovary. The nematode ovary develops much more rapidly than that of the fly, however, so that, before the eggs of the fly can be seen taking shape in the ovarian tubules, the nematode has started to lay eggs (Pl. vii, fig. 12). By the time eggs can be seen in process of formation in the ovary of the nematode, the granules of fat-body of the host insect are no longer adherent to her skin, and the fat-body of the fly has become reorganized into large compound globules.

The adult *Fergusonina* flies do not feed to any great extent, though they have been seen sucking up moisture, so it is evident that the fat-body of the fly has to supply all the nutriment for the growth of its own ovary (it is mature at emergence) and that of its contained nematodes. It is likely that the parasitic nematodes affect the egg-producing capacity of the fly in proportion to the number and size of individuals present. It happens, therefore, that, in the example dealt with in detail (*Fergusonina nicholsoni*), where only two nematodes are found normally in each female fly, an equilibrium has been reached at which the egg-laying power of the fly may be depressed, but is not impaired seriously. In other flies of the same genus, usually of larger size, the nematodes are, in some instances, bigger and more numerous. As many as seven large nematodes have been dissected out from a female fly of a leaf-gall species in which the ovaries were found to be complete, but, owing to the scarcity of fat-body, not capable of producing many eggs. The larval nematodes in the fly probably feed to some extent in their turn, but not enough to interfere materially with the development of the eggs of the fly.

The sequence of events just described forms a contrast with the state of affairs found by Goodey in his study of the Frit fly-nematode association. He found that the presence and development of the parasitic nematodes in male and female flies inhibited the development of the gonads of the hosts. When the host was able to develop its gonads to some extent before the influence of the nematodes could be felt, then the further development of the nematodes was checked—presumably by some inhibiting factor produced by the developing gonad. Just such a difference in the physiological reactions between Frit fly and *Eucalyptus*-gall fly, to a nematode parasite, might go far to explain why in the former case a destructive parasitic association only is reached, whereas in the latter, a symbiosis has been attained.

#### *Nematodes Associated with Other Species of Fergusonina.*

It is probable that further work will show that the nematodes associated with the different flies have differences in structure which entitle them to be considered as different species. There is, for instance, a considerable variation in the point of origin of the lateral alae between males derived from different types of galls. On males from the leaf galls of *E. macrorrhyncha*, the alae extend from a point opposite the nerve ring to the tail tip, whereas in the species just described, they are much less extensive. The position and size of the oesophageal glands also vary between nematodes from different galls and the parasitic females vary considerably in size in the different species of flies. The largest parasitic nematode female discovered, taken from females of *F. curriei* Tonn., measured 2.16 mm. long by 0.166 mm. broad.

#### *Taxonomics.*

The well-developed buccal stylet (Fig. 28) and the plant-parasitic habit, clearly indicate that the nematode which is being described has origin and affinities with

the plant-parasitic nematodes. A much enlarged parasitic female phase occurs in a number of nematode genera found in insects, so a consideration of each of those described previously is necessary for comparison with *Anguillulina* (*Fergusobia*).

(a) *Tylenchenema* Goodey has no buccal stylet in the male, so this leading feature may be regarded as clearly separating the new nematode from that genus.

(b) *Sphaerularia bombi* Dufour and (c) *Atractonema gibbosum* Leuckart are totally different in the form of the parasitic female.

(d) *Howardula benigna* Cobb.—The life history of *Howardula* resembles that of the new nematode in some particulars (Cobb, 1921), but the "onchium" which Cobb describes as non-bulbous is a good character for definite differentiation.

(e) *Allantonema* Leuckart and (f) *Bradynema* von Strasson have been considered as synonyms by Bayliss and Daubney. The paired, opposed, reflexed ovary of the free-living females of these genera serves to distinguish them from the new nematode.

The nematodes from *Eucalyptus* galls can, therefore, readily be distinguished from other known nematodes parasitic in insects, but they have strong affinities with the plant-parasitic group, so some consideration must be given to the genera in that group which they approach most closely.

(a)\* *Heterodera* Schmidt.—*Anguillulina* (*Fergusobia*) can be distinguished from *Heterodera*, the former having a single ovary, contrasted with the paired ovary of *Heterodera*. In addition, the dorsal gland of *Heterodera* opens at some distance from the base of the stylet, while in the other nematode the opening is close to the base of the stylet.

(b) *Aphelenchus* Bastian.—There are no knobs on the base of the stylet in this genus, a feature which serves to distinguish it from *Anguillulina* (*Fergusobia*).

(c) *Aphelenchoides* Fischer.—In this genus the opening of the oesophageal gland is at some distance from the base of the stylet and the spicules are thorn-shaped.

(d) *Anguillulina* Gervais and v. Benedin.—There are many characters, such as the knobbed stylet, the position of the opening of the dorsal oesophageal gland, the caudal alae of the male, and other characters common to both, which show affinities between the new nematode and *Anguillulina*. There are also characters such as the absence of a gubernaculum in the nematode under discussion, and the presence of an inflated degenerate female as a phase of the life-history cycle, which suggest differences almost of generic rank. In order to indicate the supposed origin and affinities of the nematode the generic name *Anguillulina* is applied, but to show the relationship with flies of the genus *Fergusonina* the name *Fergusobia* is suggested as a subgeneric title.

*Diagnosis:* ANGUILLULINA (*FERGUSOBIA*), n. subgen.

*Plant-parasitic forms.*—Small slender worms, sub-genotype described in the foregoing, about 0.4 mm. long, living in leaf galls of *E. Stuartiana* in association with larvae of flies of the genus *Fergusonina*.

♂. With well-developed stylet, the anterior part cylindrical, the base with three distinct swellings. Tail tapering behind anus and bearing caudal alae. Spicules paired and shaped like those of *Anguillulina*. Gubernaculum absent. Testis single, anterior.

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\* Generic characters of these genera are from Goodey, 1922.

♀. Stylet as in male. Ovary single, anterior, without post-uterine sac. Oviparous, 1 to 3 mature eggs visible in oviduct at one time, eggs segmenting when laid, sometimes ready to hatch. Free-living female in galls parthenogenetic in first generation.

*Insect-parasitic forms:* Sausage-shaped, much enlarged females with greatly developed ovary much coiled and filling nearly whole body space. Stylet absent in mature female. Spermatozoa visible in widened portion of uterus which acts as a receptaculum seminis. Oviparous, eggs segmenting when laid, and any number up to ten lying mature in oviduct ready to be laid.

The sub-genotype is parasitic in the body cavity of *F. carteri* Tonn. The measurements have already been given above in descriptions of stages.

#### *Types of Association Between Nematodes and Insects.*

Various types of association between nematodes and insects have been described and all instances recorded before 1927 have been collected into one publication by Van Zwaluwenburg (1928). He recognizes five types of association as follows: (1) Primary parasitism; (2) secondary parasitism; (3) internal mechanical association; (4) external mechanical association; (5) commensalism.

The nematode association with flies which we are considering does not fall into any of the foregoing categories, but it resembles, to some extent, the type of association described by Goodey (1930) between *Tylenchenema oscinellae* Good. and the Frit fly *Oscinella frit* L.

The association in the *Eucalyptus* galls is not purely parasitic, however, as it is in the example cited above, but may be regarded as a symbiosis which may have developed from a pre-existing parasitism.

#### *Origin of Fly-Nematode Association.*

The data available warrant some speculation on the probable origin of the association between the flies and nematodes in *Eucalyptus* galls.

The close affinities with modern plant-parasitic forms make it almost certain that the ancestors of the nematodes in the galls were plant parasites, and probably gall-formers closely related to *Anguillulina*.

The ancestors of the associated flies (*Fergusonina* spp.) were probably leaf-miners (leaf-mining forms are common in the family Agromyzidae), living first in the leaf and, later, in the leaf and stem-tip tissues, as these are less specialized and more available throughout the year than the flower buds. At first the association between the fly and nematode would be of an accidental type resembling the association of the nematode and Frit fly already mentioned. In such an accidental association, eventually some nematodes would penetrate the body of the fly larva, and in the highly nutritious and easily assimilable food medium, develop an enlarged and degenerate type of female, capable of producing a great number of eggs; there are many examples in the animal kingdom of this reaction to the parasitic mode of life. This very large increase in egg-laying power, together with the automatic transmission of the progeny of such a female from one generation of buds to the next, could well explain the survival of the nematodes which had developed this stage in their life history. A necessary condition for the survival of such an association, if it were to affect all of the flies, would be that the nematodes should not render their hosts totally infertile.

The foregoing sequence of events would explain the survival of those nematodes which developed this association with flies, but it does not explain why the flies containing nematodes could survive, rather than the flies acting

alone. In nature at the present time the association is complete, all fly-galls discovered up to the present containing nematodes.

It is necessary, therefore, to examine the effect of the association on the fly. In the forms studied in the present paper it was discovered that the nematodes were actively feeding and causing proliferation of the plant tissues around the egg of the fly before it hatched; and that when the fly larva did hatch, it fed on those abnormal tissue growths. This suggests the value of the nematode to the insect. From what was probably a leaf-mining form, the fly developed into a gall-living form, finding, on hatching, a suitable and easily available pabulum already provided for its first needs through the activities of the larval nematodes. A slightly higher survival rate for the newly-hatched larvae associated with the nematodes than for the larvae in plant tissues not associated with nematodes would lead ultimately to the displacement of the latter "free" types by the former "associated" types. Once the association had become established in the vegetative parts of the trees, some flies could readily attack the flower buds and establish themselves there to give rise to new species in time. Refinements in the adjustments of the nematode to the fly and of both these to the galled tissues would naturally follow. Some of the trends of these refinements are indicated by the following notes. In *Oscinella frit*, Goodey found that the nematode rendered its host infertile and that a percentage ranging from 1% to 14.7% of the flies were infected. Nematodes were found to enter and to render infertile both males and females. In all the species of *Fergusonina* the nematodes are found in the galls associated with both male and female larvae, but they are never found in the parasitic form in the male adult flies, and are always found in the female adult flies.

In the "lower" types of association, as illustrated by leaf-gall forms of *Fergusonina*, the number of female nematodes in an adult female fly may vary from three to seven, whereas in the flower-bud form already described in detail the number of parasitic nematodes is almost consistently restricted to two. There is therefore considerable evidence to support the view that the association of flies and nematodes in the galls of *Eucalyptus* trees was at first an accidental parasitism which has now developed into a symbiosis, and that the association existing at the present day in galls on the vegetative parts of the trees represents a slightly more primitive stage in the development of the symbiosis than that in the galls on the flower buds.

### III. The Galls.

#### *Gall Formation in E. macrorrhyncha.*

The flower buds generally appear in January and February on trees of this species, although there may be some variation both in the time and the amount of flower buds which the trees produce, especially under erratic rainfall conditions. The buds appear about the same time as the adult flies of *Fergusonina nicholsoni* are leaving the mature galls. The punctures made by the ovipositors of the female flies can be seen for some days after they have been made, but they do not seem to cause any special distortion of the tissues by the mechanical rupturing of the cells in their path. Eventually they heal and show only a slight scar on the operculum where they were made.

Immediately they enter the bud cavity, the larval nematodes start to feed on the ring of anther primordial cells which form a circle round the inner wall of the bud cavity. The anther primordia proliferate rapidly, forming shapeless masses of large, thin-walled, parenchymatous cells, full of mucilaginous cell-sap.



The outer wall of the bud grows in proportion to the inner proliferation, so that about a month after the nematodes and the eggs of the fly have been deposited in the buds, the galled buds can be distinguished from the ungalled buds. By the time the eggs of the fly hatch the masses of galled tissues are already present in the bud.

Evidence that the nematodes start the galling before the eggs of the fly hatch was found in the following observations. In some galled buds which were opened it was found that the fly eggs were infertile (the embryo is easily seen in fertile eggs) but the galling had already been started by the nematodes. In all such cases the galls aborted at an early stage, while the nematodes failed to reproduce and died after some months. No fly larvae have yet been found unaccompanied by nematodes, so that the fate of a fly larva, if unaccompanied by nematodes, could not be observed. Attempts to inject living nematode larvae artificially into flower buds failed.

The photo-micrograph (Pl. vi, fig. 8) of a longitudinal section of a galled flower-bud of *E. macrorrhyncha* shows the state of affairs before the egg of the fly hatches. The masses of tissue proliferating under the stimulus of the nematode irritation can be distinguished clearly.

On hatching, the fly larvae ensconce themselves between two firmly apposed masses of tissues, and there cut out small crypts. The larval nematodes migrate to these crypts to join the fly larvae, and thenceforward the fly larvae and their accompanying nematodes are to be found only in these crypts, and always together. In a single galled flower-bud there may be twenty or more of these gall-lets, each with its single fly larva and associated nematodes (Fig. 29). The crypt becomes a separate unit by the fusing of the vegetable tissues around the larva to make a spheroidal gall-let and the gall-let is attached to the wall of the bud by a strong stalk through which nourishment passes to the developing cells. A section through one of these gall-lets during the second instar period of the larva (Pl. vi, fig. 12) discloses the following formation: A distinct wall of flat cells forms the outer covering, and inside these are many layers of thin parenchymatous cells, well filled with protoplasm and mucilaginous cell-sap. On the inner surface, which is in contact with the nematodes and the fly larva, the cells are small and full of protoplasm. From these cells a mucilaginous fluid is exuded into the cavity of the gall.

This state of affairs persists through the autumn, winter, and early spring, but with the onset of summer conditions, the galls begin to mature. The outer layer of flat cells on the gall-lets becomes somewhat lignified and when the larva enters its third and final instar, it tears down the inner layers for food. At this stage the free-living nematodes are destroyed by the drying up of the gall tissues, but fertilized females have already entered the female fly-larvae.

Plate vi, figures 6-9, are photomicrographs of the different stages in the growth of the galls, while Plate vi, figure 10, shows a cross-section of a normal, ungalled flower-bud.

The photomicrograph (Pl. vi, fig. 6) shows a section of a flower bud of *E. macrorrhyncha* measuring about 1 mm. across at its widest part. Eggs had been laid in this bud by the fly, three days prior to fixation. At A can be seen the outer layer of the operculum or bud cap which, morphologically, represents the sepals. At B the inner layer of the operculum, which is considered to represent morphologically the petals of a complete flower, can be distinguished. This cap is shed at flowering, the remaining flower consisting of a multiple ring of stamens

with long filaments supporting the anthers, arising from near the lip of a cup above the ovary. At C in the section can be seen the ring of primordial tissues which give rise to these stamens. Lying in the cavity between the operculum and the base of the bud are a number of larval nematodes, N, which have already started to feed on the rapidly developing anther primordia.

Plate vi, figure 7, illustrates a more advanced stage in the development of the gall. Large irregular masses of cells can be seen proliferating into the bud cavity, where normally the stamens should be developing regularly.

Plate vi, figure 8, shows a still later stage in development of the gall. About this stage the eggs of the flies hatch and the larvae proceed to ensconce themselves between two masses of cells which are in contact. The cell masses anastomose round the crypts containing the larvae of the flies and the nematodes which have joined them. The cells immediately surrounding the larvae differ somewhat from the rest; the cell contents have a mucilaginous character, while more distant cells are more watery; likewise, the layers just round the cavity are full of protoplasm and are meristematic in character. Plate vi, figure 9, represents a still later stage in the development of the gall. At this stage the bud can be recognized from external examination to be definitely galled when compared with the normal bud. Large masses of galled tissues fill the bud cavity. Plate vi, figure 10, is a photograph of a longitudinal section of a normal bud of exactly the same age as the bud shown in Figure 9. The normal stamens can be seen lying in the bud cavity, the filaments in the upper part, and the anthers under them, while the ovules are seen in the chamber of the ovary below.

All the sections described so far have been longitudinal; the following are cross-sections: Plate vi, figure 11, illustrates a galled bud about six months old. This bud was chosen because it contained but a single gall-let and some of the stamens developed normally. This gall-let is cut through in the section at a point where the larva of the fly was not included. Nematodes can be seen lying in the cavity. In Plate vi, figure 12, the most common condition of a galled bud six months old is shown in cross-section. On this section thirteen gall-lets have been cut through at different points, eleven of them being *Fergusonina*, the other two larval wasps, shown at 1 and 4. Plate vi, figure 13, shows a single gall-let of *Fergusonina* and a single wasp chamber, for purposes of contrast.

At A can be seen the dense protoplasm-filled cells surrounding the nematodes and the fly larva. An ooze of glutinous fluid covering the surface of the cells can also be distinguished in the photograph. At B the cells are fairly dense, somewhat hexagonal, soft, and filled with clear, slightly glutinous cell sap. At C there is a layer of thick-walled cells which form the outer wall of the dipterous gall-let. They contain some brown coloration and are not sclerotized at this stage. At D is seen the larva of the fly, shrunken from the wall of the cavity by the fixing and dehydration processes. The nematodes can be seen at N surrounding the larva.

When the larva has finished feeding, only the outer lignified shell of the gall-let remains. Galled buds vary in size with the number of gall-lets contained, the normal mature flower bud measuring about 3 mm. in diameter, while a galled bud may be 14 mm. The average size of 200 galled buds of *E. macrorrhyncha* containing fly larvae and no hymenopterous insects was 5.7 mm. When hymenoptera are present as well, the galls are much larger, the average diameter for 300 galled buds containing both diptera and hymenoptera being 9.3 mm.

*Comparison of wasp galls and fly galls.*

Many galls were found on flower buds of *Eucalyptus* trees which had been formed by small hymenoptera alone, while in other instances both hymenoptera and diptera occupied the same galled buds. The short discussion which follows deals with galled buds on *E. macrorrhyncha*, which contained at the same time larvae of *Fergusonina* spp. and small hymenopterous gall-forming species.

It is of some interest to compare the type of gall tissue produced by the gall wasps with that produced by the fly larvae. This comparison will be restricted to tissues produced in the same galled bud by the two organisms, as the wasps frequently oviposit in buds already beginning to show signs of the galling caused by the flies. The cross-section (Pl. vi, fig. 13) shows, in juxtaposition, tissues galled by the wasp and those galled by the fly. The wasp larva produces a gall with a thick outer wall of heavily lignified cells and an inner mass of large thin-walled cells of spongy parenchyma, full of a watery cell-sap, and the cavity in which the larva lives is very much larger than the larva itself.

Whereas it is considered that the beginning, and a good part of the later growth, of the *Fergusonina* gall is caused by the nematodes, the wasp gall starts to form before the egg of the wasp hatches. Apparently there is some chemical stimulus to gall production, either in the egg itself or in a fluid injected by the parent wasp during oviposition. The gall reaches its full size before the larva has passed its first instar so that, after active feeding commences, there is little increase in the size of the gall, though there is probably a change in the composition of the cell contents.

Many gall-forming wasps appear to inject a fluid with their eggs, which causes the formation of the gall, while in other instances the egg itself, either by its mechanical properties or some chemical on its surface, gives origin to the galling. In the flower buds of *E. macrorrhyncha* galling started where nematodes were actively feeding and not particularly round the eggs of the flies. Moreover, the character of the gall changed after the fly larva had hatched and commenced to feed, so that apparently the first proliferation of cells was caused by the nematodes working alone, and the later development by the nematodes and fly larva working in conjunction. The ultimate cause of gall making, be it chemical or mechanical, has not been studied and no theory to explain it is advanced here. For theories on this subject, see Goodey (1935).

*Gall Formation in Other Eucalyptus Trees.*

Having treated the galls on *E. macrorrhyncha* in some detail, a little must be said about gall formation in other *Eucalyptus* trees and on situations other than the flower buds. The following table sets out the species of the genus *Fergusonina*, the larvae of which have been described in the present paper, and the species of adults which have been described by Tonnolr (1937), together with the species of trees and the situations on which they have been found.

TABLE 1.—(*Genus*) *Fergusonina*.

Species.	Host.	Galls.	Adult.	Larva.
<i>microcera</i> Mall. ( <i>Genotype</i> )	—	—	+	—
<i>atricornis</i> Mall.	—	—	+	—
<i>flavicornis</i> Mall.	—	—	+	—
<i>scutellata</i> Mall.	—	—	+	—
<i>biseta</i> Mall.	<i>E. maculata</i>	? flower-bud	+	—
<i>gurneyi</i> Mall.	<i>E. maculata</i>	? flower-bud	+	—
<i>eucalypti</i> Mall.	<i>E. maculata</i>	flower-bud	+	+

TABLE I.—Continued.

Species.	Host.	Galls.	Adult.	Larva.
<i>carteri</i> Tonn.	<i>E. amygdalina</i>	?	+	+
	<i>E. Stuartiana</i>	leaf		
<i>evansi</i> Tonn.	<i>Eucalyptus</i> sp.	leaf	+	+
<i>davidsoni</i> Tonn.	<i>E.</i> sp.	? leaf	+	—
<i>brimblecombei</i> Tonn.	<i>E. melanophlota</i>	flower-buds	+	+
	<i>E. hemiphylota</i>	"		
	<i>E. crebra</i>	"		
	<i>E. odorata</i>	"		
<i>morgani</i> Tonn.	<i>E. hemiphylota</i>	flower-bud	+	—
<i>percotti</i> Tonn.	<i>E. amygdalina</i>	leaf	+	—
<i>newmani</i> Tonn.	<i>E. gomphocephala</i>	leaf-bud	+	+
<i>lockharti</i> Tonn.	<i>E. rudis</i>	stem-tip	+	+
<i>frenchi</i> Tonn.	<i>E. amygdalina</i>	leaf	+	—
<i>nicholsoni</i> Tonn.	<i>E. macrorrhyncha</i>	flower-bud	+	+
<i>curriei</i> Tonn.	<i>E. macrorrhyncha</i>	leaf	+	+
<i>tillyardi</i> Tonn.	<i>E. Blakelyi</i>	flower-bud	+	+
	<i>E. camaldulensis</i>	"		
	<i>E. tereticornis</i>	"		
<i>graevesi</i> Curr.	<i>E. polyanthemus</i>	stem-tip	—	+
sp. 1	<i>E. pauciflora</i>	stem-tip	—	+
sp. 2	<i>E. macrorrhyncha</i>	stem-tip	—	+
sp. 3	<i>E. sideroxylon</i>	leaf	—	+
	<i>E. maculosa</i>	"		
	<i>E. melliodora</i>	"		
	<i>E. macrorrhyncha</i>	"		
sp. 4	<i>E. maculosa</i>	leaf	—	+
sp. 5	<i>E. pauciflora</i>	flower-bud	—	+
sp. 6	<i>E. maculata</i>	axil-bud	—	+
sp. 7	<i>E. Stuartiana</i>	leaf and leaf-stem	—	+

The flower buds of *E. Blakelyi*, *E. camaldulensis*, and *E. tereticornis* are all galled by the same species of fly, *F. tillyardi* Tonn., and the galling proceeds as follows:

The nematodes start the galling and the fly larvae hatch out afterwards and commence to feed, then the nematodes join them in their small crypts and the galled buds increase in size. Whereas in *E. macrorrhyncha*, the crypts are each separated into gall-lets by the formation of a layer of flat cells making a limiting membrane, no such membrane is formed in the flower buds of the other trees mentioned, but the whole of the tissues on the galled buds fuse together into a mass which is bounded only by the outer walls of the flower buds. Inside this more or less homogeneous matrix of soft parenchymatous tissues, and scattered through the whole, are to be found the crypts in which larvae and nematodes live. In cross-section it is seen that some layers of cells surrounding each of the larval crypts are filled with more dense protoplasm and cell-sap than the tissues of the matrix.

During the first and second larval instars in autumn, winter, and spring, the galled tissues are soft and glutinous. With the advent of summer and the larval change to the third instar, the tissues begin to harden and to dry up. When the larvae are full fed, the tissues forming the matrix between crypts dry up and the whole gall disintegrates rapidly, so that there are numerous avenues of escape for the adult flies. The photographs (Pl. vi, figs. 3 and 4) show the galled, contrasted with the ungalled, buds of *E. Blakelyi*. Galled buds of the three trees mentioned may reach a diameter of 18 mm., while the ungalled buds average about 3 mm. in diameter. The galled buds of *E. maculata* are similar in development and structure to those of *E. Blakelyi*.

Next to *F. tillyardi*, which is found on *E. camaldulensis*, *E. tereticornis* and *E. Blakelyi*, the most common fly found so far in flower buds is *F. brimblecombei* Tonn., which is found in *E. hemiphloia*, and *E. odorata*, *E. crebra* and *E. melanophloia*. The galls formed by this fly are somewhat different in structure from those formed on *E. camaldulensis*. Instead of forming a homogeneous mass inside the galled bud as in *E. camaldulensis*, the stamens in the species of *Eucalyptus* trees named above develop to some extent. The tissues which hypertrophy in this instance belong to the walls of the calyx-cup and the ovary. At maturity, the operculum, which is not fused to the rest of the gall, opens and the flies escape into the space occupied by the stamens by the break-down of the galled tissues, and thence, via the opercular opening, to the exterior. Galled buds of *E. hemiphloia* are about 8 mm. in diameter, while *E. maculata* and *E. odorata* produce galls up to 20 mm. in largest diameter.

The galls formed on leaf and stem-tip tissues are generally irregular and warty in appearance. They are simple in construction, each larva occupying an individual chamber in which it lives with the nematodes. Examples of this type are found on the leaf tips of *E. gomphocephala* and *E. maculosa*.

Another type of gall is formed on the shoot tip of *E. macrorrhyncha* and on *E. rudis*. This consists of a large mass of spongy tissue containing a number of larvae and surrounded by a clearly-defined, pigmented, tough outer skin (Pl. vi, fig. 5). The larvae and accompanying nematodes live near the centre of the galled mass until the former are near the point of pupation, when each larva tunnels an individual track to just under the skin, where it pupates. On the leaves of *E. Stuartiana* and other *Eucalyptus* trees, the galls are formed between two developing leaves which, on fusing together, form the upper and lower ends of a series of gall cavities (Pl. vi, fig. 5).

*Regular Galls.*—All the galls mentioned so far are shapeless and irregular, but two examples of regular, though not complex, galls have been observed. One of these is a stem-tip gall formed on *E. polyanthemos* (Fig. 30). The gall illustrated shows clearly, when mature, the light patch on the side which is to be the emergence hole of the adult fly. The other example is provided by the axil buds of *E. maculata* (Fig. 31). These are individual spherical galls with emergence holes prepared by the full-fed larvae before pupation.

There are no rich architectural designs produced by *Fergusonina* spp. to compare with those made by the many gall-making coccids of the genus *Aptomorpha*, so well known on *Eucalyptus* trees in Australia.

#### FLUCTUATIONS IN THE NUMBERS OF GALLS FROM SEASON TO SEASON.

During certain years galling of the flower buds of some eucalypts was extremely heavy, particularly on *E. camaldulensis*, *E. hemiphloia*, *E. tereticornis*, *E. Blakelyi*, and *E. macrorrhyncha*. In other years considerable areas had to be searched before galls could be discovered, even when flower buds were abundant. These violent fluctuations in numbers were much more evident in the flower-bud galls than on the stem and leaf-tip galls, and the latter were never seen in such overwhelming numbers as the flower-bud galls. In examining the causes of this phenomenon it would appear that there is a more constant high level of parasitic control on the less specialized stem-tip, and leaf-tip galls, than on the relatively more specialized flower-bud galls. The incidence of parasites will be considered separately, but it is necessary to mention it here because there is no doubt that parasites exercise considerable influence in deciding the amount of galling under certain conditions.

As an actual observation of the fluctuation of the numbers of galls the sequence of events on a single tree of *E. macrorrhyncha* may be quoted:

During 1930, although buds were present in fair numbers, there were no galls formed on the tree.

In 1931 there were fewer flower buds formed but only a small number of these were galled.

In 1932 there was a heavy crop of flower buds and the galling was so complete that scarcely a bud reached the normal flowering stage. Galls were mostly of mixed origin, flies and wasps both being present.

In 1933 the galls containing wasps still hung on the tree from the previous year, but only a very small number of new buds were formed. These were galled by the flies which were then emerging in large numbers, but hardly any of the galls reached maturity.

In 1934 there were many flower buds on the tree, but none was galled.

Early in 1935 new buds formed and none of them was galled, but the tree died. The extremely heavy galling in 1932, especially the excessive number of wasp galls, which seemed to take more out of the tree because of their longer (2 year) duration, appears to have weakened the tree, which had also been attacked by a fungus, thus contributing to its death.

The setting of flower buds on *Eucalyptus* trees is not very regular, the amount of bud setting being dependent on the locality, the amount and distribution of rainfall during the previous and in the current year, and the other climatic conditions during the period. Buds may be formed every year on *E. macrorrhyncha*, or, in unfavourable seasons, scarcely any buds may form on the trees at all. Flowering takes place in the Federal Territory generally during February or March, and the young buds which will flower during the year following usually appear earlier in the year. One may frequently see, in March, a single tree carrying flowers fully out, flower buds which had set the previous January, and flower buds six months old.

The conditions necessary for heavy galling of flower buds in any one year are: (1) The trees must bear a heavy crop of flower buds; (2) large numbers of gall flies must be present near the trees (the gall flies are not strong fliers); (3) the flies must emerge from last year's galls just at the same time as the young flower-buds are appearing on the same, or on other trees.

Taking these conditions in order, we see that owing to the erratic flowering of the *Eucalyptus* trees, a year or two may pass before a heavy crop of buds appears, so that the possible total number of flies may be regulated by the number of flower buds available. In particularly bad years, buds may be so scarce that the fly population is reduced to a very low level.

The second condition (No. 2 above) has a twofold demand. First, large numbers of flies must be present in galls from the previous year, which means that the previous year must have produced a fair number of galls, and second, the flies must be within range of the new buds. It is a matter of common observation that certain localities have a somewhat different flowering rhythm from others, so that these districts may, under certain adverse circumstances, become so unfavourable for the flies that they cease to exist there, and the areas have to be slowly re-colonized from elsewhere. Speaking very broadly, it is true that whole climatic regions in Australia have regular fluctuations in the numbers of flower buds present, but, within these, smaller localities do exist which vary away from this regular sequence. As an example of the possible non-fulfilment of the condition named in (2), it was observed that a group of trees of the species

*E. Blakelyi* bearing many buds was untouched by galling in 1932, while only a mile away galling was heavy on another group of trees of the same species. The following year the group of trees which was carrying a heavy crop of galls produced vast numbers of flies, but no tree of that group produced any flower buds, and trees only a mile distant, which bore buds, were not galled.

The third condition is a most important one which is frequently not fulfilled. In *E. macrorrhyncha* the buds galled by the fly open to permit the escape of the flies before the normal flowering time of the trees, and just before young buds appear. The short life of the adult fly makes it imperative that the interval between emergence and the appearance of the buds should be not more than a month, so that if the tree from which the flies emerge does not bear young buds that year, then neighbouring trees must bear buds about the same time to allow survival. Normally, trees of the same species flower, and bud, about the same time, but, for reasons not as yet explained, the flowering time may be spread over a long or a short period. The ideal conditions for heavy galling in any year occur when trees bud simultaneously, and when budding corresponds to the time of emergence of the flies.

A year of heavy budding may give a heavy galling, but very seldom do successive seasons produce heavy crops of buds in most districts, so a maximum galling year produces flies which usually find the following year a restricted number of buds in which to lay, and so may be reduced in numbers that year to a minimum. This minimum is in no danger of complete annihilation as there are always some trees, or at least some branches on certain trees, which produce buds out of season, or during a season when other trees fail to do so. From this minimum a series of moderate budding years followed by a well-timed, maximum budding year are required for the flies to reach maximum abundance again, and it most frequently happens that some vicissitude, such as the non-fulfilment of correlation in time or space between flies and buds, prevents the flies from having maximum numbers in each year of maximum buds. Fortunately for the beekeeper who depends on a heavy crop of blossom for his honey harvest, it is the exception rather than the rule to get maximum galling coincident with maximum flower-bud production.

In some districts in which conditions are very favourable to *E. camaldulensis*, a good deal of bud formation takes place every year, with a certain biennial maximum budding, super-imposed on the annual. In such a district a good deal of galling is always present, with an occasional heavy maximum.

The biennial life cycle of some of the wasps so frequently associated with the flies in galling complicates the matter further. Many years of quantitative study would have to be made, however, before an authoritative statement about the relative importance of the rôles played by the various insects concerned in the galling could be arrived at. The availability of suitable breeding places is considered by the author to be the principal factor contributing to the big fluctuations in the numbers of flies from year to year in the flower-bud-galling species.

The flies using leaf bud, shoot tip, and other vegetative parts of the tree on which to form galls have never been seen to reach the same great abundance as the flower-bud-galling species, although they may often be common, as they are sometimes on the leaves of *E. Stuartiana*. The reason for this is probably twofold. In the first place, suitable young shoots or leaf-buds are subject to wide variations in abundance from year to year but not to the same extent as the flower buds. In the second place, parasites appear to play a bigger part in keeping the numbers

to a more even, steady density on the vegetative than in the reproductive galls. The part played by parasites may therefore be considered as a separate section.

#### PARASITES AND OTHER INSECTS IN RELATION TO ABUNDANCE OF FLIES.

Some chalcid gall-formers have been bred out from the same galls in *E. macrorrhyncha* as the *Fergusonina* flies. These insects were not direct parasites but competitors within the galls, the effect of their inhabiting the same galls affecting the numbers of flies emerging. The gall wasps lay their eggs, mostly in buds already galled by the flies, and the larvae hatching from the wasp eggs produce separate gall chambers which have already been described in detail. These chambers have strong, hard walls which were impenetrable barriers to gall flies ready to emerge if they happened to be in their path. In addition to this, all the buds galled by the wasps became very woody so that the operculum was fused to the body of the gall, and consequently could not open to release the flies at the appointed time. Large numbers of flies were entombed in the galls by this means, and died there. The only chance they had of emerging was when a wasp, more advanced in its life history period than the others, cut a tunnel to the exterior through the wall of the gall, so that flies which happened to be mature at the time this hole was cut, and which were close to the hole, could squeeze through. The wasps have not been found in such great numbers on many trees, but on one tree observed, the branches were weighed down with galls and about 60% of the flies were unable to emerge owing to the presence of the wasps. The chief wasps concerned in this galling were *Epimegastigmus quinqueactae* Grl., *Ditropinotella compressiventris* Grl., *Eurytoma varirufipes* Grl., and an unidentified species of *Megastigmus*.

In addition to those chalcid wasps which lived in the same galls as the flies, many true parasites were bred out. One of the commonest chalcids was *Coeloclyba eucalypti* Grl. Others have not been identified yet.

One of the larger insects bred out was a braconid wasp, the larva of which was found to feed indiscriminately on gall tissues and fly larvae. A full study of the hymenopterous fauna of the galls is reserved for a future occasion, so only the general observations can be recorded here.

It was found that in the bigger flower-bud galls the small chalcid parasites occurred mainly on larvae situated in the loculi near the outer surface of the bud. The larvae living deeper in the gall were free from most types of parasites, although they were preyed on by some predators, such as the braconid already mentioned. The parasites did not appear to be able to reach such a large percentage of the fly larvae in the flower-bud galls as in the leaf and stem-tip galls.

During 1934 a large number of galls were found on the leaves of *E. Stuartiana*. Parasites were common on them, so that from the galls about equal numbers of hymenopterous parasites and flies emerged. Galls were scarcer on trees of this species during 1935, in spite of the fact that much young growth appeared on the trees, growth which appeared suitable for galling. It was observed, however, that most of the flies emerged in 1934 during May, when there was little young growth available, so that a failure of co-ordination in time took place. Those galls which did appear in 1935 were examined, and in most of them nematodes were found with hymenopterous larvae or pupae. The empty skin of a larval fly of *Fergusonina* was found in each gall chamber, so it was clear that parasitism was very heavy.

From observation over a considerable period, and over a wide area, it would appear that parasites play an important rôle in controlling the steady density of



these leaf-galling species because, although they are liable to fluctuations, due to changes in the amount of available suitable vegetative parts in which the larvae can develop, those fluctuations do not bring them either to such large or to such small numbers as the flower-bud species.\* They are able always to maintain a widespread rather low density and the continuous availability of hosts gives the parasites opportunity for a fairly constant measure of control.

#### *Summary and Conclusions.*

Many galls on leaves, stem tips, leaf buds and flower buds of *Eucalyptus* trees are caused by the combined action of nematodes and small flies of the Agromyzid genus *Fergusonina*. The flies and nematodes are invariably found together in the gall, and their relationship is described as a true symbiosis.

The association is clearly of long standing and probably originated in an accidental parasitism by the ancestors of the nematodes which had been plant-parasites, on the ancestors of the flies which were probably leaf-tunnellers.

The life histories of the flies and the nematodes have been worked out and their interdependence revealed.

The fly larvae, which are described for the first time, carry chitinous structures on the dorsum which are of great taxonomic value and phylogenetic interest.

The nematodes are found in the galls as free-living females and males. The first generation living in the galls is composed of parthenogenetic females, and there is an alternation of generations during which a generation of fertilized females is parasitic in the adult fly. The adult fly deposits the nematode larvae in buds with her own eggs.

The taxonomics and affinities of the nematodes are discussed and a new subgenus *Anguillulina* (*Fergusobia*) is erected to contain them.

Insect parasites of the flies are common and their significance in controlling the numbers of flies is discussed.

Large fluctuations in the number of gall flies occur from season to season. In the flower-bud gall-forming species the erratic bud formation of the *Eucalyptus* is considered to be the factor mainly responsible for the fluctuations. In the leaf and stem-tip gall-formers, which are nowhere so plentiful as the flower-bud types, although availability of suitable young growth controls the numbers to some extent, parasites are thought to effect a considerable measure of control.

#### *Acknowledgements.*

Thanks are due to Dr. A. J. Nicholson, Chief of the Division, and Dr. I. M. Mackerras, for critical revision of the manuscript and for considerable help in the presentation of material; to Mr. J. W. Evans for giving up material on which he had started to work when he knew the author was making a special study of the problem; and to my colleague, Mr. A. L. Tonnoir, for describing the adult flies. To all those throughout Australia who supplied material I express my thanks.

My colleagues of the Division have assisted generously in many ways during the progress of the investigation, and their lively interest gave me continual encouragement; to Mr. W. J. James I am indebted for taking the photographs which have been presented in the plates.

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\* For a full discussion of the subject of fluctuations in animal populations due to various causes reference should be made to Nicholson (1933).

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## EXPLANATION OF PLATES VI-VII.

## Plate vi.

- Fig. 1.—Galled (left) and young ungalled (right) flower-buds of *E. macrorrhyncha*.  $\times 0.4$ .
- Fig. 2.—Branches of *E. macrorrhyncha* carrying many galls.  $\times 0.06$ .
- Fig. 3.—Normal flower-buds of *E. Blakelyi*.  $\times 0.6$ .
- Fig. 4.—Galled flower-buds of *E. Blakelyi*.  $\times 0.09$ .
- Fig. 5.—Leaf-galls on *E. Stuartiana* (centre and left); shoot-galls on *E. macrorrhyncha* (right).  $\times 0.2$ .
- Figs. 6-13.—Photomicrographs of galled flower-buds of *E. macrorrhyncha*.
- Figs. 6-12: A, outer layer of operculum; B, inner layer of operculum; C, anther primordium; N, nematode larvae; L, larva of fly; 1 and 4, wasp gall cavities.
- Fig. 13: A, inner layer of cells with dense protoplasm surrounding fly gall cavity; B, middle layer of cells in fly gall cavity; C, outer limiting layer of cells in fly gall cavity; L, fly larva; N, nematodes; H, thin-walled parenchyma in wasp gall cavity; W, outer woody layer of cells bounding wasp gall cavity. Figs. 6, 13,  $\times 12$ ; figs. 7-12,  $\times 6$ .
6. Young flower bud in which eggs of fly and nematode larvae had been laid three days previously. 7. Flower bud with tissues proliferating. 8. A more advanced stage. At this stage the eggs of the fly hatch. 9. More advanced stage of galling. 10. Normal flower bud same age as galled bud in Fig. 3. 11. Cross-section of galled flower-bud with only one gall cavity containing nematodes. This section misses the fly larva which accompanied nematodes. 12. Cross-section of galled flower-bud showing many gall cavities containing fly larvae and nematodes, and two wasp gall cavities. 13. Cross-section showing contrast between vegetable tissues surrounding the fly larva and nematodes, and the wasp larva.

## Plate vii.

- F.O., ovary of fly; F.E., egg of fly; N, larval nematodes; E, egg of nematode; F, globule forming part of fat body of fly.
- Fig. 1.—Adult female of *Fergusonina*.  $\times 13$ .
- Fig. 2.—Ovaries of fly dissected out showing nematode larvae protruding from torn oviduct.  $\times 17$ .
- Fig. 3.—Photomicrograph showing eggs of fly in ovary and a nematode larva between them.  $\times 100$ .
- Fig. 4.—Photomicrograph of elements from haemocoel of fly.  $\times 100$ .

Figs. 5-12.—Photomicrographs of nematodes:

5. Free living female,  $\times 125$ . 6. Male,  $\times 100$ . 7. Parasitic female from body of fly larva which was about to pupate moulting into final instar,  $\times 150$ . 8. Parasitic female growing rapidly; stylet in this stage still apparent,  $\times 75$ . 9. Parasitic female nearly full grown; stylet has disappeared and gut almost completely atrophied. From puparium of fly,  $\times 100$ . 10. Parasitic female at later stage than Fig. 9. From puparium of fly,  $\times 50$ . 11. Parasitic female fully developed and most of her eggs already laid. From adult female fly *P. tillyardi*,  $\times 35$ . 12. Fully developed female from body cavity of adult fly *P. carteri*,  $\times 50$ .

## NOTES ON FOSSIL DIATOMS FROM NEW SOUTH WALES, AUSTRALIA. I.

FOSSIL DIATOMS FROM DIATOMACEOUS EARTH, COOMA, N.S.W.

By B. V. SKVORTZOV, Harbin, Manchoukuo.

*(Communicated by Dr. A. B. Walkom.)*

(Twenty-six Text-figures.)

[Read 28th July, 1937.]

The diatomaceous remains found in siliceous earths, clay, sands and similar deposits of the later geological periods have recently become of great importance in deciding whether these deposits were formed under marine, brackish-water or freshwater conditions, and even in ascertaining the proportion of salt contained in the water in which they were deposited. Moreover, as the geographical distribution of the living species of diatoms becomes known, valuable indications may be obtained from the presence of their remains, as to the climates that prevailed while the deposits which contain them were being laid down. The recent and the fossil diatomaceous floras of Australia have not yet been extensively studied. Investigations of the recent and fossil freshwater diatoms of Australia include those of G. I. Playfair (1915) on the diatomaceous flora of the Lismore district, G. S. West (1909) who described some forms from the environs of Melbourne, and Tempere and Peragallo (1915) on collections of fossil diatoms from Brunswick, Victoria, from Lake Marl, and from Talbot, Melbourne, and of fresh and brackish-water species from the Yarra River, Melbourne. A detailed investigation of the marine diatoms from the water off the coast of New South Wales has recently appeared (Dakin and Colefax, 1933). The present note is the result of the examination of diatomaceous earth from Cooma kindly sent to me by Mr. F. S. Mance of the New South Wales Department of Mines, Sydney. This deposit is situated about five miles from Cooma, and one and a half miles from Bunyan Platform, N.S.W. The following description of this deposit is given by Dr. W. R. Browne (1914, p. 205): "From test-holes which have been put down, the deposit is believed to cover an area of 80 acres. It is situated in a hollow on the western side of Middle Flat, surrounded on the north and west by a ridge of slates and mylonized quartz-porphyry capped by Tertiary basalt. The deposit is close to the surface, being covered by 18 inches to 2 feet of alluvium, chiefly basaltic soil. Under this is about 2 feet of very hard buff-coloured "mullock", a kind of travertine containing numerous angular fragments of quartz and of diatomaceous earth. This is succeeded by another 2 feet of massive tripolite of a pale creamy-white colour, then comes 3 feet of layered tripolite—"slate", as it is called—which is slightly denser than the other and shows stratification. Under this the deposit is alternately massive and stratified. At intervals, pipes of roughly elliptical section occur, filled with a hard, brittle brown clay, in which remains of bones, etc., are often found. Veins of wood opal are fairly frequent, yellow, red, and green in colour, and very light and brittle." E. J. Kenny (1924, p. 12) gives analyses of three diatomites from Cooma. The diatomaceous earth from Cooma is whitish-cream in colour, very light, porous, somewhat friable, resembling chalk in general appearance. The study of the sample was done in my private laboratory

at Harbin. The crude material was first broken into small pieces and pulverized with Glauber's salt. For this the material was mixed with Glauber's salt and boiled several times during a week. The rapid crystallization of the salt breaks the pieces of diatomaceous earth into fine powder. Then the material was washed in distilled water and boiled in commercial hydrochloric acid, then washed again and boiled in commercial sulphuric acid. Then powdered potassium chlorate was slowly added to the boiling acid until the black colour gave place to white. Very thorough washing followed this to remove the last trace of acids and salts. The coarse pieces, as spicules of sponges and like impurities, are now removed by rotating the material in a glass tube. The diatoms were then preserved in 96% alcohol and mounted in Piperin-Cumaron and Hgl<sub>2</sub> proposed by Dr. R. W. Kolbe of Berlin.

The following general features may be pointed out in connection with the examination of the algal flora of the Cooma diatomaceous earth:

1. The Cooma diatomaceous earth is probably of middle Tertiary age and of distinct lacustrine origin. In this earth ten species of diatoms have been recognized, together with many sponge spicules, some cysts of Chrysomonads and auxospores of undetermined diatoms. Most of the diatoms were present only as small filaments and could not be identified. Of the diatoms found, 25% are new; 60% of the algae belong to recent species, 30% are known as fossil from Lower Tertiary deposits.

2. In external appearance the diatomaceous earth exhibits a great degree of uniformity and consists of a large number of *Melosira granulata* and var. *angustissima*, a freshwater species reported as recent from the plankton of large lakes of temperate regions of Europe, America and Asia, and known as fossil in neogene deposits from Europe, Korea, Nippon, and North America. The other species are all infrequent and rare in the material from Cooma.

3. *Melosira undulata* var. *spiralis* is also a freshwater species reported as recent from tropical districts as Malaya, India, West India, Nippon, South China and Africa, and is widely known as fossil from neogene deposits from Europe, America, Northern China and Nippon. Our Cooma specimens differ from the type only in the structure of the frustules.

4. *Eunotia valida*, *Pinnularia viridis* var. *intermedia* and *Gomphonema longiceps* var. *subclavata* are all freshwater. *Stauroneis* (*Pleurostauron*) *Playfairiana* is a distinct species, probably also freshwater.

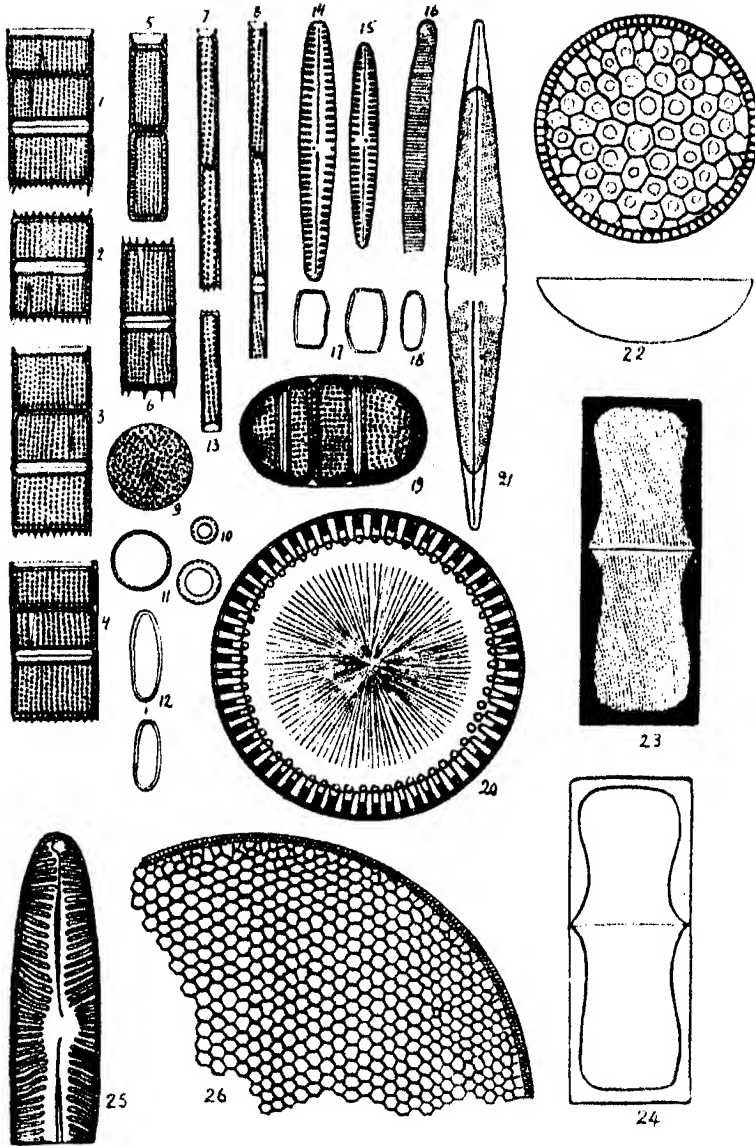
5. Large numbers of fragments of several kinds of diatoms belonging to the genera *Synedra*, *Fragilaria*, *Pinnularia*, *Cymbella* and others have been observed in the material but are not identifiable. They are all freshwater.

6. Three distinct marine diatoms have been recognized from Cooma. *Melosira sulcata* is common in Pacific, Atlantic and Arctic oceans and also reported as fossil from Lower Tertiary deposits from New Zealand, Tertiary deposits of Hungary, and from marine deposits of Simbirsk, Russia. *Coscinodiscus Wittianus* Pantocsek has been reported from Lower Tertiary deposits from Simbirsk, Russia, and *Coscinodiscus subconcarus* is also known from Tertiary deposits of European Russia. Future investigations may show whether the occurrence of these marine diatoms in the lacustrine diatomaceous earth is accidental.

#### Description of the species.

*MELOSIRA GRANULATA* (Ehr.) Ralfs. Text-figs. 1-6, 9, 11, 13.

Hustedt, Bacillar., 1930, pp. 87-88, fig. 44; Hustedt, Die Kieselalgen, 1927, Lief. 1, pp. 248-249, fig. 104 a-c. c. f.



Text-figs. 1-26.

1-6, *Melosira granulata* (Ehr.) Ralfs.—7, 8, *Melosira granulata* (Ehr.) Ralfs var. *angustissima* O. Mull.—9, *Melosira granulata* (Ehr.) Ralfs.—10, *Melosira granulata* (Ehr.) Ralfs var. *angustissima* O. Mull.—11, *Melosira granulata* (Ehr.) Ralfs.—12, Sporangial frustule of an unidentified diatom.—13, *Melosira granulata* (Ehr.) Ralfs var. *angustissima* O. Mull.—14, 15, *Gomphonema longiceps* Ehr. var. *subclavata* Grun. ?.—16, *Eunotia valida* Hustedi.—17, 18, Sporangial frustule of unidentified diatom.—19, *Melosira granulata* (Ehr.) Ralfs. Sporangial frustule.—20, *Melosira sulcata* (Ehr.) Kutz.—21, *Stauroneis* (*Pleurostauron*) *Playfairiana*, n. sp.—22, *Coscinodiscus subconcoavus* Grun.—23, 24, *Melosira undulata* (Ehr.) Kutz. var. *spiralis*, n. var.—25, *Pinnularia viridis* (Nitzsch.) Ehr. var. *intermedia* Cleve ?.—26, *Coscinodiscus Wittmanus* Pant.

The drawings were made with E. Leltz Apochromat 2 mm. and compens. ocular 4.

Valve cylindrical with distinct pseudosulcus and sulcus. Edge of disc with spines, usually small, sometimes large. Frustule membrane thick, with large granules in longitudinal, sometimes spiral, lines. Frustule height 0.0085 to 0.02 mm.; breadth, 0.0068 to 0.0187 mm. Rows of granules 9 to 10, granules in rows 9 to 13 in 0.01 mm. Abundant. A freshwater diatom reported from plankton of lakes. Known as fossil from neogene deposits of Europe, North America, and recently from Korea, and Nippon (Saga Prefecture).

*MELOSIRA GRANULATA* (Ehr.) Ralfs var. *ANGUSTISSIMA* O. Mull. Text-figs. 7, 8, 10, 13.

Hustedt, Bacillar., 1930, p. 88, fig. 45; Hustedt, Die Kieselalgen, 1927, p. 250, fig. 104d.

Valve linear-cylindrical. Frustule height 0.02 to 0.022 mm.; breadth, 0.0034 to 0.005. Rows of granules 9, granules in rows 10 to 12 in 0.01 mm. Common with the type. Reported from plankton of large lakes, and fossil from neogene deposits. Recently found in neogene deposits of Chosen, Korea, Nippon.

*MELOSIRA UNDULATA* (Ehr.) Kütz. var. *SPIRALIS*, n. var. Text-figs. 23, 24.

Differ a typo striis spiralis non parallelis, 18 in 0.01 mm. Punctis 20 in 0.01 mm. Punctis robustis solitariis juxta discum absunt. Habit.: In stratis tertiaris aquae dulcis prope Cooma, New South Wales, Australia.

Frustules single or in twos, usually longer than broad, with thick membrane constricted near the margin. Pseudosulcus and sulcus indistinct. Surface of the valve with spiral lines of puncta. No large puncta near the edge of the disc. Frustule height 0.025 to 0.027 mm.; breadth, 0.01 mm. Rows of puncta 18, puncta in rows 20 in 0.01 mm. Differs from the type and varieties in its spiral, not parallel, lines of puncta and by the absence of large puncta near the edge of the disc. Infrequent. *Melosira undulata* is a freshwater form and is common in tropical districts; it is also known as fossil in neogene deposits of Europe, North America, Shantung, N. China, and Nippon.

*MELOSIRA SULCATA* (Ehr.) Kütz. Text-fig. 20.

Van Heurck, Synopsis, 1881, Taf. 91, figs. 15, 16; A. Schmidt, Atlas Diatom., 1882, Taf. 176, figs. 28, 32-39, 42-44, 46; Taf. 178, figs. 1-5, 7-19, 22-24.—*Melosira sulcata* Ehr. var. *sibirica* Grun., Witt, Ueber den Pollerschiefer von Archangelsk-Kurojedowo im Gouvern. Simbirsk, 1885, 28, Taf. X, fig. 2.—*Melosira sulcata* Ehr. f. *radiata* Grun., Peragallo, Les Diatomées Marine de France, 448, Pl. 119, fig. 12.

Valve circular, robust, 0.068 to 0.075 mm. in diameter, separated into three areas. The marginal area, about one-ninth of the diameter of the valve, is formed of robust radiating plates, shorter and longer, striped lengthwise with a series of large rounded dots between the large plates in the inner part of the area. Marginal plates 4 to 5 in 0.01 mm. The median area, also about one-ninth of the valve diameter, is hyaline, and the central area, about two-thirds of the valve diameter, is covered with fine radiating rows, about 8 to 9 in 0.01 mm. Infrequent. A marine species, recent and fossil. Reported from Lower Tertiary deposits from New Zealand, also from Tertiary deposits of Hungary and of Simbirsk, European Russia.

*COSCINODISCUS WITTIANUS* Pant. Text-fig. 26.

Beitrage zur kenntniss der Fossilen Bacillarien Ungarns, 1903, 120.—*Coscinodiscus lineatus* O. Witt (nec Ehrenberg), Ueber den Pollerschiefer von Archangelsk-Kurojedowo im Gouvern. Simbirsk, 1885, 28, Tab. I, fig. 6.

Valve circular. Surface towards the centre flat, slightly convex near the border. Markings hexagonal, 2.5 to 3 in 0.01 mm., subequal, at border 8-9 in 0.01 mm. Central dots of the markings indistinct; apiculi absent. Border narrow, with small markings, without radiating striae. Diameter 0.119 to 0.122 mm. Infrequent. Differs from the type in larger size of the valve and more robust markings.

*COSCINODISCUS SUBCONCAVUS* Grun. Text-fig. 22.

Rattray, A revision of the Genus *Coscinodiscus* Ehr. and of some allied genera. 1890, 466; A. Schmidt, Atlas Diatom., 1878, Pl. 59, figs. 12, 13.

Frustule convex, about 0.037 mm. in diameter. Valve circular, covered with large hexagonal markings, decreasing but slightly from the centre outwards, about 2 in 0.01 mm. Central dots distinct. Border narrow, showing evident short radial lines. Rare. Reported from Lower Tertiary deposits of Simbirsk, European Russia.

*EUNOTIA VALIDA* Hust. Text-fig. 16.

Hustedt, Bacillar., 1930, 178-179, fig. 229.

Valve linear, slightly curved, with parallel margins and slightly capitate ends. Length, 0.045 mm.; breadth, 0.005 mm. Striae about 12 in 0.01 mm. Infrequent. A freshwater species reported from Europe.

*STAURONEIS (PLEUROSTAURON) PLAYFAIRIANA*. n. sp. Text-fig. 21.

Valvis lanceolatis angustis, ad medium modice inflatis cum poltis cuneatis et subacutis. Area axillaris angustis linearis ad polos laculamentis ornatis, area centralis ad porum centralem transverse dilatatus. Striis transversis radiantes, punctatis, 16-18, punctis 15 in 0.01 mm. Polos hyalinis, raphe directis. Valvis longis 0.075-0.09 mm.; latis 0.009-0.01 mm. Habit.: In stratis lacustris tertiaris prope Cooma, New South Wales, Australia.

Valve linear-lanceolate, tapering from the middle part to the long acute ends. In the middle part of the valve the margin slightly interrupted. Both ends with transverse round siliceous ribs. Median line straight. Central pores distinct. Axial area narrow linear, central area a transverse dilated fascia. Striae radiate, 16-18 in 0.01 mm. Puncta distinct, about 15 in 0.01 mm. Length, 0.075 to 0.09 mm.; breadth, 0.009 to 0.01 mm. Differs from *Stauroneis (Pleurostauron) acuta* in its long acute ends. Infrequent. Named in honour of the late G. I. Playfair.

*PINNULARIA VIRIDIS* (NITZ.) Ehr. var. *INTERMEDIA* Cleve (?). Text-fig. 25.

Cleve, Synopsis of the Navicul. Diatoms, 1894, I, 91; Pantocsek, Beiträge zur kenntniss der Fossilen Bacillarien Ungarns, 1903, III, Pl. 7, fig. 119.

Valve elliptical-linear with margins attenuated towards rounded ends. Length, 0.072 mm.; breadth, 0.0136 mm. Median line robust, indistinctly complex. Terminal fissures comma-shaped. Axial area linear, about one-fourth of the breadth of the valve, widened around the central nodule. Striae 8 in 0.01 mm., divergent in the middle and convergent at the ends. Longitudinal band distinct. Infrequent. A freshwater diatom, reported also as fossil.

*GOMPHONEMA LONGICEPS* Ehr. var. *SUBCLAVATA* Grun. (?). Text-figs. 14, 15.

Hustedt, Bacillar., 1930, 375, fig. 705.—*Gomphonema subclavatum* Grun., Van Heurck, Synopsis, 1880, Pl. 23, fig. 37.

Valve lanceolate, clavate, with one end broader than the other. Apex attenuate and acute. Length 0.0357 to 0.0476 mm.; breadth 0.005 to 0.006 mm. Striae robust,



almost parallel, at the end slightly radiate, 6 to 10 in 0.01 mm. Infrequent. A freshwater diatom common in mountain districts, and also reported as fossil.

*Sporangial frustules of an unidentified diatom, probably of ATTHEYA sp.*

Text-figs. 12, 17, 18.

Cells in front view barrel-shaped, in side view elliptical, with thick smooth membrane. Cell in front view 0.009-0.01 to 0.005-0.0068 mm., in side view 0.0042-0.0051 to 0.0085-0.0187 mm. Common.

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## A MONOGRAPH OF THE AUSTRALIAN COLYDIIDAE.

By H. J. CARTER, B.A., F.R.E.S., and E. H. ZECK.

(Plates viii-ix; two Text-figures.)

[Read 25th August, 1937.]

The accumulation of unnamed material and the need for greater accuracy in the nomenclature make it desirable to attempt a survey of this group, a work approached with much diffidence, but rendered possible by the courteous and able help of K. G. Blair and J. G. Arrow of the British Museum, who have identified and compared with type many examples sent to them. This has been supplemented by the gift or loan of specimens that illustrate genera rare or unknown in Australian collections. We are also indebted to Mr. Womersley and the Trustees of the South Australian Museum for the loan of a large collection of this family, which includes some cotypes of Blackburn and Lea. Also the National Museum, Melbourne, the Macleay Museum and the Australian Museum, Sydney, the Queensland Museum, Brisbane, and the Council for Scientific and Industrial Research, Canberra, have all helped by the loan of material. We are also indebted to F. E. Wilson, whose specimens, being in perfect order, simplified their examination.

Previous work in this family has been of a somewhat intermittent kind. Amongst Australian authors, Blackburn is the most prolific. Two genera, *Deretaphrus* and *Bothrideres*, are especially common and widely distributed throughout Australia, under the bark of suitable Eucalyptus trees. As with other common insects, they are subject to great variations of size and colour. The many minute members of the family are much neglected except by expert collectors. The labels of the late A. M. Lea and Dr. E. W. Ferguson, and of our friends F. E. Wilson, Dr. K. K. Spence and J. Armstrong, abundantly show this amongst the many hundreds of specimens examined.

A remarkable feature is the very wide distribution of species. Species described by Sharp from Japan, by Pascoe from Malaya, by Grouvelle from Ceylon and elsewhere, occur in Australia. This probably accounts for much of the synonymy in the family. There is no evidence of this wide distribution being otherwise than natural.

*Classification of the Australian Colydiidae.*

Grouvelle included the sub-families Euxestinae and Murmidinae in this family. The former is not included in our Monograph through lack of material and the existing doubt as to its correct family position. The latter contains no

Note by H. J. Carter: The greater part of the systematic work of the following has been done by myself. But I am greatly indebted to E. H. Zuck for his dissections of tarsal and other structures in the smaller species; for his inimitable drawings of these and of the figures of the new species; also for much helpful advice. These things have so much added to the value and accuracy of the paper that it is right to include his name as joint author.

recorded Australian species. With these omissions the family is subdivided into two sub-families, distinguished as follows:

Insertion of the antennae hidden by the lateral border of the front ..... I. *Colydiinae*.  
Insertion of the antennae visible ..... II. *Ceryloninae*.

#### I. *Colydiinae*. Table of Tribes.

1. Antennae capitate .....	2
Antennae not capitate .....	5
2. Anterior and post coxae close .....	<i>Synchittini</i>
Anterior coxae distant .....	3
3. First tarsal segment not longer than second .....	4
First tarsal segment longer than second .....	<i>Acropini</i> *
4. Scutellum present .....	<i>Pycnomerini</i>
Scutellum absent (in the only Australian genus) .....	<i>Coxellini</i>
5. Antennae 11-articulate .....	6
Antennae 10-articulate (fusiform) .....	<i>Orthocerini</i>
6. Antennae perfoliate .....	<i>Rhagoderini</i> †

#### II. *Ceryloninae*. Table of Tribes.

1. Apical segment of antennae not acicular .....	2
Apical segment of antennae acicular .....	<i>Cerylonini</i>
2. Front coxae close .....	<i>Deretaphrini</i>
Front coxae distant .....	3
3. Form elongate, glabrous .....	<i>Bothriderini</i>
Form ovate, with velvety derm .....	<i>Dastareini</i>

Of the sub-family *Colydiinae* the majority of Australian genera are included in the *Synchittini* and may be tabulated as follows:

#### *Synchittini*.

1. Antennal club 3-clavate .....	2
Antennal club 2-clavate .....	3
2. Anterior coxal cavities open .....	<i>Sparactus</i>
Anterior coxal cavities closed .....	<i>Larinotus</i>
3. Antennal apical segment well-defined .....	4
Antennal apical segment very small and obscure .....	12
4. Prothorax and elytra costate .....	5
Prothorax and elytra not both costate .....	7
5. Elytral costae regular (uninterrupted) .....	6
Elytral costae irregular and interrupted .....	<i>Phorminx</i> , n.g.
6. Margins of prothorax narrow, antennal sulcus ill-defined .....	<i>Bitoma</i>
Margins of prothorax wide, antennal sulcus well-defined .....	<i>Phormesa</i>
7. Prothorax only costate .....	<i>Synagathis</i> , n.g.
Neither prothorax nor elytra costate .....	8
8. Form narrow, prothorax with narrow lateral foliation .....	9
Form wider, prothorax with wide lateral foliation .....	10
9. Body pilose, base of prothorax without border .....	<i>Neotrichus</i>
Body setulose, base of prothorax bordered .....	<i>Sympanotus</i>
10. Lateral margins of prothorax more or less lobate .....	<i>Ablabus</i>
Lateral margins entire .....	11
11. Prothorax and elytra with parallel sides .....	<i>Cobia</i>
Form ovate, prothorax with well rounded sides .....	<i>Colobicus</i>
12. Tarsal formula normal 4-4-4 .....	<i>Bupala</i>
Tarsal formula 3-3-3 .....	<i>Pabula</i> , n.g.‡

\* The two genera placed under *Acropini* in the Junk Catalogue are so different as to suggest a reclassification, thus—

*Meryx*: Antennae perfoliate, all coxae close.

*Todima*: Antennae bi-clavate, all coxae distant.

† *Ocholiassa* is unclassified (*Incertae sedis*) in Junk, but the perfoliate antennae, their insertion distant from the eyes and not retractile under the head, the head somewhat narrowed behind, and anterior coxae open, suggest inclusion under *Rhagoderini*.

‡ *Pabula* would seem to require a special Tribe for its reception. For the present it is sufficiently distinguished here.

The Tribe Deretaphrini includes the following genera which may be tabulated as follows:

- |  |                    |
|--|--------------------|
| 1. Antennae with 11th segment a mere excrescence on the 10th, form cylindric ..... | <i>Oxytaemus</i>   |
| Antennae not so .....  | 2                  |
| 2. Basal segment of tarsi elongate, antennal club ovate .....                      | <i>Metopiestes</i> |
| Basal segment of tarsi short, antennae subclavate .....                            | <i>Deretaphrus</i> |

The two genera of the Tribe Bothriderini, *Bothrideres* and *Machlotes* Pasc., are readily distinguished by the strong transverse sulcus near the base of the prothorax, in the latter.

The two genera of the Cerylonini may be tabulated thus:

- |  |                     |
|--|---------------------|
| Antennae 11-articulate, bi-clavate .....             | <i>Phllothermus</i> |
| Antennae apparently 10-articulate, uni-clavate ..... | <i>Cerylon</i>      |

#### BITOMA Herbst.

The distinction between *Bitoma* and *Phormesa* is very finely drawn by the absence or presence of an antennal sulcus and the less defined prothoracic margins of the former; but the exact constitution of the former of these features is not easy to define.\* In every insect of the group Sychitini that we have examined there is a depression between the eye and submentum in which the basal part of the antennae rests. Authors write of this sulcus as obsolete, short or long. We have not met with the first; in *Bitoma angustula* Motsch., *B. serricollis* Pasc., and *B. costata* MacI. (the last incorrectly placed, we think, under *Phormesa* in the Junk Catalogue), this depression is at its minimum. To the above three species we add three new ones, *cylindrica*, *occidentalis* and *puteolata*. *B. villosa* Lea is an *Ablabus*. *P. (B.) parva* Blkb. is either a *Phormesa* or requires a separate genus (see below).

#### Table of species of Bitoma.

- |  |  |
|--|--|
| 1. Prothorax longer than wide .....                                    | 2  |
| Prothorax not so .....   | 3  |
| 2. Pronotal costae separate and parallel .....                         | <i>occidentalis</i> , n. sp.                     |
| Two inner costae partly connected .....                                | <i>cylindrica</i> , n. sp.                       |
| 3. Pronotum deeply excavate along middle .....                         | <i>puteolata</i> , n. sp.                        |
| Pronotum not so .....  | 4  |
| 4. Margins of prothorax and elytra sharply serrate .....               | <i>serricollis</i> Pasc.                         |
| Margins of prothorax and elytra finely crenate .....                   | 5  |
| 5. Form depressed ( <i>Phormesa</i> -like) .....                       | <i>costata</i> MacI.                             |
| Form subcylindric ( <i>Xuthia</i> -like) .....                         | 6  |
| 6. Pronotal costae bent outward (inner costae bifurcate at apex) ..... | ? <i>angustula</i> Mots.; <i>parallela</i> Shrp. |
| Pronotal costae bent inwards (inner costae bifurcate at base) .....    | <i>siccana</i> Pasc.                             |

Synonymy.—*B. serricollis* Pasc. = *lineatocollis* Blkb.

? *B. angustula* Motsch. = *parallela* Shrp.

*B. siccana* Pasc. = *rufina* Pasc. = *maura* Pasc.

The briefly described *angustula* Motsch. is suggested by Grouvelle as synonymous with *parallela* Shrp., but the type is apparently lost.

#### BITOMA CYLINDRICA, n. sp. Plate viii, fig. 4.

Elongate, parallel; head and pronotum nitid black, elytra, appendages and underside reddish.

\* See also Grouvelle's note (*Trans. Ent. Soc. Lond.*, 1918, p. 10) on *Ditoma crenata* Herbst. "type du genre *Ditoma*" . . . "en réalité cet insecte a des rudiments de sillons antennaux qui permettent aux antennes de venir s'étendre dessous la tête pendant la position de repos".

*Head* subquadrate, with raised lateral edges; finely punctate, antennae having two basal segments stout and cylindric, 3-9 moniliform and closely set, 10-11 forming a compact oval club. *Prothorax* convex, parallel, longer than wide, apex and base bisinuate, anterior angles well advanced and acute, posterior angles produced but blunted; surface consists of 10 carinate ridges, the two interior curved and lyriform, produced along apical and basal border to meet the 4th, subplanate on apical region, here bifurcating to form the 2nd parallel carina, these not extending to base or apex, 4th and 5th sharply carinate, forming a concave lateral edge; the 3rd sinuous and less conspicuous in the wide sulcus between the 2nd and 4th ridges; the raised area formed by the junction of 1st and 2nd sparsely punctate. *Scutellum* oval with a wide triangular excavation behind it. *Elytra* convex, cylindric, seriate-punctate, the punctures close, large and square, separated by cancellate ridges, the alternate intervals raised, forming carinae at base and on apical declivity. *Head* with a minimum of antennal grooves, *palpi* subulate at apex. *Prosternum* transversely striolate, *metasternum* sparsely, *abdomen* more closely punctate, the punctures on abdomen diminishing in size and density towards apex, abdominal segments subequal. *Dim.*— $3\frac{1}{2}$ -5  $\times$  1.3 mm. (approx.).

*Hab.*—Queensland National Park (H.J.C., also in Queensland Mus.), Cairns (A. M. Lea), Dorrigo (Heron), Illawarra (H. Cox and J. J. Walker), Richmond R. (A. M. Lea).

Eighteen examples, varying in size, have been examined that belong to Pascoe's *Nuthia* group of *Bitoma*. Holotype in Coll. Carter.

*BITOMA OCCIDENTALIS*, n. sp. Plate viii, fig. 1.

Elongate, subcylindric, chocolate-brown; antennae and legs red.

*Head* subquadrate, clypeus truncate, diagonally impressed at front corners; frontal surface with flattish pustules, sides raised, eyes moderately prominent; antennae: 1 and 2 stout, 3-9 small and close, 10-11 forming a large, loose club. *Prothorax* longer than wide, as wide as head at eyes; parallel, apex with discal part carinate and subtruncate, front angles subacute, lightly advanced, hind angles subrectangular, lateral margins convex between two narrow carinae, base with discal part carinate and lightly produced backward; disk with six subparallel and lightly raised costae (besides the two lateral), the 1st and 3rd (from middle) continuous with apical and basal carinae, the 2nd not meeting either, the two innermost lightly diverging in front and behind, interspaces irregularly rugose-pustulose. *Scutellum* oval; a sutural excavation behind it. *Elytra* parallel, scarcely wider than prothorax, each with 4 costae, the 1st (sutural) meeting 2nd at apex, 3rd and 4th not extending to apex; between each pair of costae a double row of large square punctures; the sutural costae lightly diverging behind scutellum, leaving room for a short extra row of punctures. No defined antennal sulcus, but antennae when at rest partly contained in hollow inside eye. *Dim.*—4 mm. long.

*Hab.*—Western Australia: Mount Barker (A. M. Lea); Tasmania: Launceston (British Museum).

Two examples, in the South Australian Museum and the British Museum respectively, show an ally of *B. cylindrica* in form, but differ in colour and in the less deeply sculptured pronotum, the costae being clearly separated and parallel, besides other differences noted above. Holotype in S. Australian Museum.

*BITOMA PUTEOLATA*, n. sp. Plate viii, fig. 12.

Short, oblong, castaneous; pronotal costae edged with black.

*Head* subquadrate and concave, with a triangular clypeal area raised, the lateral margins sharply carinate, surface finely granulose; antennae: basal segment hidden, 2 and 3 longer than 4, 4-8 close, 9 wider than 8, 10-11 forming a stout club, 10 lunate, 11 round. *Prothorax*: apex strongly sinuate, the medial discal margin with a concavity, the front angles lightly advanced and subacute, base with medial lobe forming a short rectangle behind the hind angles; widest in front, sides feebly arcuate, narrowed from apex to base, foliate margins subhorizontal, below the plane of disk, extreme margins crenulate; disk quadricostate, the two interior costae sinuately widened at middle, narrowed at base and apex, two exterior costae straight, rounded in front to meet interior costae, at base the interior costae turn outwards to meet the exterior; medial area deeply excavated, with a double row of rugose punctures on each side of excavation, the intercostal spaces and foliate margins also rugose-punctate. *Elytra* wider than prothorax at base, sides subparallel, feebly widened behind middle; each with three sharp costae besides the less raised sutural margins; interspaces with a double row of large, round punctures. *Prosternum* densely punctate; metasternum finely setose, abdomen minutely granulose-setose. *Dim.*—2½ mm. long.

*Hab.*—Queensland National Park, MacPherson Range.

Two examples are remarkable for the deeply pitted pronotum. Holotype in the Queensland Museum.

#### SYNAGATHIS, nov. gen. Synchronorum.

Oblong, moderately convex; eyes large and prominent, palpi simple, pointed at apex, mentum transverse; antennae stout, 11-articulate, biclavate, 10th and 11th segments large and loosely connected. Tibiae, triangularly enlarged at apex, with small apical spine. Antennal sulcus scarcely defined. All coxae approximate, post intercoxal process triangular. Prothorax with lateral margins crenulate, disk formed by two rounded costae enclosing two dumb-bell-like impressions. Elytra parallel, striate-punctate.

A genus near *Bitoma*.

#### SYNAGATHIS KAURICOLA, n. sp. Plate viii, fig. 5.

Oblong; prothorax lightly, elytra more strongly convex, above and below red, glabrous and nitid, cavities of pronotum partly black.

*Head* subquadrate, clypeus semicircular, surface uneven, with large, irregularly-placed punctures; sides raised behind eyes and hollowed within the lateral ridges; antennae stout, 1 hidden, 2-3 rather tumid, 2 larger than 3, 4-9 moniliform, close, lightly, successively enlarged, 10-11 forming a loose club, 10 wider than 11. *Prothorax* subquadrate, subtruncate at apex and base, sides, in general, nearly straight (in one example the right-hand side is irregularly incurved near the middle), margins regularly crenulate, anterior angles rounded off, posterior subrectangular a little blunted at tip; disk on higher plane than margins, with rounded, rib-like lateral costae, rounded in front, produced behind beyond margins, with blunted rectangular hind-angles; medial area occupied by two dumb-bell-like impressions, with deep arcuate cavities, a small, granulose ridge within the sub-lateral cavities connected with lateral costae. *Scutellum* globular; a triangular area hollowed out behind it. *Elytra* little wider than prothorax, sides parallel, apices conjointly rounded; striate-punctate, a double row of deep punctures between subcostate intervals, four on each, including raised suture. *Underside* lightly, sparsely punctate. *Dim.*—3 mm. long.

*Hab.*—N. Queensland (C. French Junr.).

Three examples from the South Australian Museum bear a label "Under bark of Kauri logs from Cairns, at Melbourne. C.F.Jr." A second label, in the handwriting of the late A. M. Lea, states: "Queensland. C. French Jr. obtained in Q. logs at Melbourne". The Queensland Kauri (*Agathis robusta*) suggests the generic name. Holotype in the South Australian Museum.

LARINOTUS, n. gen. Synchronorum.

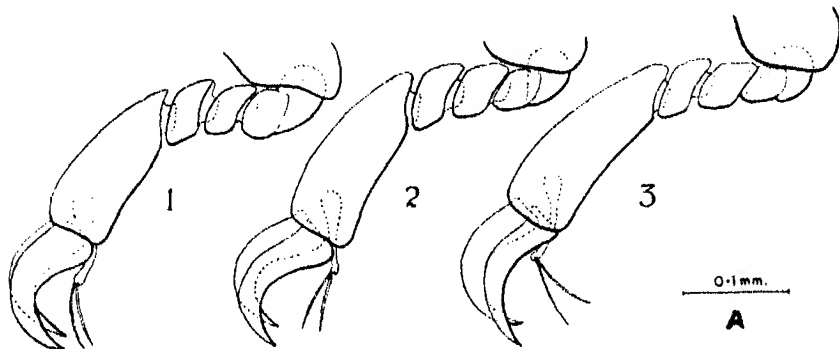
Head wide; antennae apparently 10-11 segmented, triclavate; antennal sulci distinct. Body short, stout, oblong, strongly convex laterally, pilose; all coxae moderately close; anterior acetabula closed.

An anomalous genus, in form suggestive of *Cicones* and its allies, but with wider head and different antennae.

LARINOTUS UMBILICATUS, n. sp. Plate viii, fig. 12; Text-fig. A.

Oblong, transversely convex; subnitid brown to black above, nitid black beneath, palpi, antennae and tarsi red; strongly pilose.

Head subvertical, clothed with rough derm, setose, clypeus subtruncate, eyes large and prominent; antennae: basal segment very stout, 2 smaller, oval, 3-7 small, close and round, 8-10 forming a robust, compact club. Prothorax strongly transverse, medial lobe produced over head, anterior angles obtuse, not prominent; widest behind middle, sides lightly rounded, foliate margins obliquely depressed, border crenulate, disk closely covered with rounded pustules, each bearing a long, upright hair, some coarser hair on front border. Scutellum transverse, oval, pustuliform. Elytra wider than prothorax at base, sides sub-parallel, whole



Text-figure A.—*Larinotus umbilicatus*: 1st, 2nd and 3rd tarsus drawn from micro-slide. Details of claw attachments and setae omitted.

surface with longitudinal series of umbilicate pustules, with signs of striae connecting these; each pustule with a small puncture bearing a pale, upright hair; those on medial region sparse or abraded, longer and more evident laterally. Anterior coxal cavities closed behind, mandibles bifid, maxillary palpi with last segment ovate-acuminate; antennal sulcus short. Prosternum rugose-foveate-punctate; anterior coxae widely separate; mesosternum and episterna with coarse punctures; metasternum with deep oval sulcus in middle; post coxae rather close, its process rhomboidal, abdomen with scratch-like markings, clad with long hairs; tibiae with short apical spur, tarsi (post) with first 3 segments short and subequal.

*Hab.*—N. S. Wales: Dorrigo (W. Heron). Two examples. We can not make out more than 10 segments to the antennae. Its 3-segmented club, short tibial spurs and other details suggest its position. Holotype in Coll. Carter.

## SPARACTUS ER.

*Illestus* Pasc. (vide Blackb., *Trans. Roy. Soc. S. Aust.*, 1902, p. 315).

The Australian species are singularly varied in size and form, *elongatus* Blkb. being more than twice the size of *interruptus* Er., while *pustulosus* Blkb. might well be generically separated. Lacordaire's tabulation of the genera would place *elongatus* under *Pristoderus* Hope, a genus now placed as a synonym of *Ulonotus* and sufficiently distinguished from *Sparactus* by the form of the head. Two new species are added below to the five recorded by Junk. The following will help to separate the species:

*Sparactus* Er.

- |  |                                |
|--|--------------------------------|
| 1. Margins of prothorax divided (lobate) .....           | <i>pustulosus</i> Blkb.        |
| Margins of prothorax not divided .....                   | 2                              |
| 2. Size large (5-7 mm. long) .....                       | <i>elongatus</i> Blkb.         |
| Size smaller .....                                       | 3                              |
| 3. Elytra with costate intervals .....                   | 4                              |
| Elytra with nodulose intervals .....                     | 5                              |
| 4. Each elytron with 3 costae .....                      | <i>productus</i> Reitt.        |
| Each elytron with 2 costae and a row of granules .....   | <i>queenslandicus</i> , n. sp. |
| 5. Margins of prothorax much widened at apex .....       | 6                              |
| Margins of prothorax little widened at apex .....        | <i>proximus</i> Blkb.          |
| 6. Elytra lightly convex, punctate between nodules ..... | <i>interruptus</i> Er.         |
| Elytra strongly convex, granulose between nodules .....  | <i>leai</i> , n. sp.           |

Synonymy: *S. interruptus* Er. = *grouvellei* Reitt.

*S. productus* Reitt. = *costatus* Blkb.

## SPARACTUS LEAI, n. sp. Plate viii, fig. 6.

Ovate; dark brown above, appendages and underside red.

*Head* subquadrate, slightly widened in front of eyes, and with a pronounced latero-basal tubercle above the eyes, surface granulose, antennae as in the common *S. interruptus* Er. *Prothorax* convex, widest in front, the apex strongly bisinuate, acutely and obliquely produced at the angles, also produced strongly in middle, sides arcuately narrowed and concave to base and rather irregularly crenulated by blunt pustules; hind angles acute and pointing outward, base strongly bisinuate, the medial lobe widely arched; disk strongly raised by ridges forming four sides of a hexagon, with an elongate depression at middle, narrowed in front to form a wide open sulcus and meeting near base, the ridges here again bifurcating triangularly to base; whole surface strongly granulose. *Elytra* convex, much wider than prothorax at base, shoulders rather square, slightly widened behind middle, each with rows of elongate nodules, the first row containing three, of equal length, the basal one extending to front margin; the second row with 3 or 4 shorter nodules, the third row, extending from the shoulders, forming more or less a subcontinuous costa, the suture little raised. Between the rows are two lines of seriate granules, alternating with depressions simulating punctures. Pro- and meta-sternum also finely granulose and very sparsely pubescent. *Dim.*—3 mm. long.

*Hab.*—North Queensland: Cairns district (A. M. Lea).

Several examples, taken by the late eminent entomologist, are in the collection of Colydiidae sent from the South Australian Museum. The species is of the *S. interruptus* type, but differs in (1) its much more convex form, (2) the more defined sculpture of prothorax, (3) the pronounced nodule above eyes, (4) different elytral sculpture. Holotype, marked on card of series of 6, in South Australian Museum.

[*N.B.*—*S. interruptus* Er., described as from Tasmania, occurs commonly in all the States on the mainland of Australia.—H.J.C.]



## SPARACTUS QUEENSLANDICUS, n. sp. Plate VIII, fig. 2.

Opaque; brownish-black above, underside and appendages red.

*Head* quadrate, sides with raised parallel ridges, surface finely pustulose-punctate, antennae stout, club formed by two transverse cup-shaped segments and a large oval terminal one. *Prothorax* widest at front, anterior angles lightly produced, subacute, sides arcuately narrower from apex to base; base feebly bisinuate, hind angles widely obtuse, foliate margins serrulate; disk with a rounded (sub-rhomboidal) depression at middle, bounded by obscure ridges, these narrowed to meet apex and base in subparallel lines, the basal pair narrower than apical. *Elytra* seriate-punctate, the seriate punctures large, round and regular, with three equidistant intervals slightly raised above the rest, at extreme base becoming short costae, also a little prominent on apical declivity, the two intervals nearest suture formed by rows of granules. Prosternum transversely rugose, the rest of underside finely granulose; prosternum with a small process jutting beyond the coxae. *Dim.*—4.5 × 1½–2 mm.

*Hab.*—Queensland: Yeppoon (H. J. Carter).

Two examples taken under bark, in October, 1924 (H.J.C.). By Lacordaire's table the species should be a *Pristoderus*, but it is, we consider, congeneric with *S. elongatus* Blkb. and *S. proximus* Blkb. Holotype in Coll. Carter.

## PHORMESA PASC.

In this genus the antennal sulcus is well defined. Thus in *P. prolata* Pasc. it is emphasized by a ridge which follows its internal border for some distance. In repose the antennae lie along this, the apical club being folded horizontally at base of head.

[I think I know all the recorded species from Australia (except *P. thoracica* Blkb.), together with two others, *prolata* Pasc. and *lunaris* Pasc. that were described from Malaya or New Guinea.—H.J.C.]

The only species that corresponds, in dimensions, to *thoracica* amongst Australian species, is *prolata* Pasc., but this is more strongly sculptured than *torrida* Blkb., with the posterior angle of prothorax acute, both characters inconsistent with Blackburn's notes. We are thus compelled to omit *P. thoracica* from our table.

*P. prolata* Pasc. is very common in the Cairns district. [I have seen many examples in the various collections.—H.J.C.]

*P. lunaris* Pasc.—A single example from Cairns is hypothetically determined for a species, in the South Australian Museum, that is of a pale ferruginous colour, of wide form, with discal costae little developed and an undefined pattern on the elytra that may be the "semi-lunar band" of the author.

The distinction between *Microprius* Grouv. and *Phormesa* Pasc. seems so tenuous as to require justification. We have not been able to find this distinction classified. Grouvelle does not include *Phormesa* among the Colydiidae of the Indian Region, while Sharp does not include it among the Colydiidae of Ceylon or Japan; yet he erected a new genus *Trionus* which, by figure and description, appears inseparable from *Phormesa*, but is placed under *Microprius* in the Junk Catalogue. Three examples from Cairns, in the material before us, that correspond with the excellent figure of *Trionus opacus* Shrp. are included in the following table, together with two new species.

Table of *Phormesa* Pasc.

1. Upper surface variegated or maculate .....	2
Upper surface concolorous .....	3
2. Elytral markings more or less fasciate .....	3
Elytral markings with maculae .....	5

3. Sides of prothorax well rounded, form wide ..... *lunaris* Pasc.
  - Sides of prothorax nearly straight, form narrow ..... 4
  4. Elytra largely occupied by two red fasciae ..... *carpentariae* Blkb.
  - Elytra chiefly dark, with vague, transverse maculae ..... *torrida* Blkb.
  5. Head with lateral lobe ..... 6
  - Head without such lobe ..... 7
  6. Elytral apices produced (sublobate) ..... *caudata*, n. sp.
  - Elytral apices normal ..... *parva* Blkb.
  7. Prothorax widest at base, thence arcuately narrowed to apex ..... *prolata* Pasc.
  - Sides of prothorax nearly straight ..... 8
  8. Prothorax widest at apex ..... *hilaris* Blkb.
  - Prothorax widest at middle ..... *notata*, n. sp.
  9. Pronotum with four strong costae, with other elevations ..... 10
  - Pronotum with two moderate costae and rudiments of two others, without other elevations ..... *epithea* Oll.
  10. Sides of prothorax rounded, elytral intervals granulose ..... *grouvellei* Blkb.
  - Sides of prothorax nearly straight, elytral intervals cancellate-punctate ..... *(Trionus) opacus* (?) Shrp.
- Synonymy: ? *Phormesa* (*Holopleuridia*) *imperialis* Reitt. = *P. torrida* Blkb.  
*P. prolata* Pasc. = *P. heros* Pasc. = *P. varia* Pasc.

*PHORMESA* (?) *CAUDATA*, n. sp. Plate viii, fig. 8.

Narrowly oblong, attenuate at apex; subnitid brownish-black, raised parts piceous, antennae and legs, also margins of thorax, red, elytra with pale spots.

*Head* elongate-subrectangular, asperate from its scaly hirsute clothing, lateral margins raised, eyes prominent, a lobate process protruding beyond hind half of eyes; antennae: basal segment hidden, 2 thicker than 3; 3-8 small, closely set, 9 rather larger than 8, 10-11 forming a club, 11 much smaller than 10. *Prothorax* subquadrate, discal area roundly produced and raised at apex, merely produced at base; anterior angles lightly advanced, rounded at tips, the posterior sharply rectangular. The horizontal foliate margins on a lower plane than disk, and slightly enlarged in front, its margins nearly straight, and sharply serrated. Disk with costate lines forming an oval 'plaque' from apex to basal fourth. From here two short costae form a basal triangle, the exterior margin of disk also marked by crenulate costae, more or less parallel to the foliate margins, but narrowed and rounded at apex. *Elytra* slightly wider than prothorax, narrowed, sublobate and separately rounded at apex; each with four strong costae, besides the less raised sutural margins, the latter diverging to form a narrow triangle near scutellum; the costae crenulated by deeply impressed punctures on each side, the exterior costa forming a sharply serrated margin, depressed intervals with a variable number of testaceous spots (in the most clearly marked example two on the sutural, four on each of the two succeeding intervals). *Dim.*—2½-3 mm. long.

*Hab.*—Adelaide (Sharp Coll.), also Pascoe Coll. without locality label.

Four examples examined are among the British Museum examples sent. It is clearly allied to *P. (Bitoma) parva* Blkb. by antennal structure and the lobate process at base of eye, but also clearly separated from that species by the curious apical structure, narrow form, and spotted elytra. There is a distinct antennal sulcus. Holotype in the British Museum.

*N.B.*—The distinction between *Microprius*, *Trionus* and *Phormesa* seems to be very finely drawn. *Trionus* has been already merged with *Microprius* in the Junk Catalogue.

*PHORMESA NOTATA*, n. sp. Plate viii, fig. 11.

Oblong-ovate; dark brown, clypeus, foliate margins of prothorax and appendages red. Elytra with testaceous spots.

*Head* flat and subquadrate, minutely granulose and sparsely pubescent; antennae: segments 1 and 2 wide, evident from above, 3-9 moniliform and close, 9 slightly larger than 8, 10 and 11 forming a stout club. *Prothorax* strongly transverse, apex bisinuate, front angles advanced and acute, the medial part well advanced, sides nearly straight, arcuately narrowed to both angles, posterior angle obtuse, base lightly bisinuate; foliate margins rather wide, extreme border minutely crenulate, disk lightly convex with a medial round, concave lozenge, bounded by vaguely raised lines, open in front and behind, the lines in front parallel, those behind approximate and parallel for a short way, then diverging to the base, the hinder lines forming two smaller loops at the base of the medial lozenge; sides of disk limited by sinuate costae, having a wide re-entrant angle at the middle; general surface asperate and subopaque, very minutely granulose. *Elytra* slightly wider than prothorax, each with the suture and three other intervals costate, the sutural costa divaricate behind the scutellum; between the costae two rows of punctures, having two elongate maculae, somewhat variable in number but placed on the intercostal spaces as follows (in a well-marked example): on subsutural interval one at middle, another near apex; on 2nd interval one on apical and basal third respectively; on 3rd interval one in advance of those on 2nd interval; on 4th interval one slightly behind those on 3rd. Under-side opaque and almost impunctate, a few small punctures on prosternum. *Dim.*—4-5 mm. long.

*Hab.*—N.S.W.: Kindee (H. J. Carter), Sydney (Dr. K. K. Spence), Richmond R. (in Brit. Mus.), Bogan R. (J. Armstrong); Queensland: Cairns (A. M. Lea), Goodna (F. E. Wilson); N.-W. Aust. (in National Museum).

Nineteen examples before us are allies of *P. torrida* Blkb., from which it differs by its much less strongly sculptured thorax and elytra, with a somewhat similar pattern; also, in *torrida* the red marks on elytra are subfasciate. *P. prolata* Pasc. is a larger species with strongly raised ridges and vaguely maculate elytra; *P. hilaris* Blkb. is a narrower species in which the maculae are round and red and the pronotum without a defined pattern. Holotype in Coll. Carter.

*Var.*—The single example from N.-W. Aust. is almost black, more nitid, and with fewer maculae than in other examples, but is clearly conspecific.

#### PHORMINX, nov. gen. Sychitidnorum.

Oblong-obovate; surface asperate and opaque, with thick derm, scale-like hairs and granules. Eyes not prominent. Antennae 11-articulate, the two apical segments forming a large, compact club. Antennal sulcus well defined. All coxae approximate, legs stout, tibiae rounded, not greatly enlarged at apex, without apical spur. Prothorax very convex, foliate margins irregularly serrate, disk with two irregular, longitudinal ridges. Elytra somewhat violin-shaped, with numerous costae irregular in length.

A genus perhaps nearest *Phormesa*, with a unique sculpture.

#### PHORMINX LYRATA, n. sp. Plate viii, fig. 9.

Oblong-obovate; opaque chocolate-brown; antennae, tarsi, margins of prothorax and the depressed parts of elytra red.

*Head* subquadrate, clypeus subtruncate; surface granulose; antennal segments 1-2 stout (1 unseen from above), 3-9 subequal, 10-11 forming a stout club. *Prothorax* convex, especially towards apex. Apex moderately bisinuate, angles slightly advanced and directed diagonally outward, base rather strongly produced backward in the middle, the obtuse posterior angles considerably in advance of

the medial lobe; sides subparallel, deeply, irregularly serrated, with about 5 or 6 teeth of variable width; foliate margins moderately wide and horizontal; disk uneven and convex, medial area with two confusedly arcuate ridges with elongate depression between them on apical half, approximate and parallel on basal third, again bifurcating to form a triangle at base; surface irregularly granulose. *Elytra* somewhat compressed at middle, widened at shoulders and, more strongly so, behind; with 6 short costae on basal fourth, the exterior one following the squarish humeral curve, the interior one extending from base to basal fourth and strongly raised on its hinder part; between the two former a short, less evident costa near base; two arcuate costae near the exterior of convex portion of elytra, extending from behind the basal costae and terminating in a prominent ridge on apical declivity; another pair of short, prominent ridges on apical declivity, half-way between suture and exterior ridge; suture lightly raised; general surface with series of large punctures separated by transverse rugosities with some granules here and there. Underside scabrous and impunctate; abdominal segments of equal width. *Dim.*—3.8–5 mm. long.

*Hab.*—N.S.W.: Williams River (Lea and Wilson) in Coll. Wilson, Dalmorton and Wollongong (A. M. Lea) in S.A. Mus., Raymond Terrace (J. Armstrong); Queensland: Tambourine Mt., Nanango, and Maleny (H. Hacker).

Fourteen examples examined deserve generic distinction by their unusual sculpture. Holotype in Coll. Wilson (his specimens being in perfect condition).

*BUPALA AUSTRALIS*, n. sp. Plate viii, fig. 3.

Oblong, convex; reddish-brown above, with short, white, scaly bristles, under-side darker.

*Head* subquadrate, subvertically placed, eyes large, rather prominent, surface dotted with fine, white scales; antennae 10-articulate, two basal segments stout, 3–8 equal and close, 9 slightly larger than 8, 10 forming a large round club. *Prothorax* widest at base, thence lightly narrowed to apex; discal part of apex produced over head, the angles emarginate, subacute (blunt at tips), base arcuately produced backward, post angles obtuse and slightly rounded, sides nearly straight, margins subfoliate, the foliation only evident near front, extreme border finely serrate and ciliate; disk convex, with a feeble depression near middle, surface everywhere with short, pale, scaly bristles. *Elytra* of same width as prothorax, with about 10 rows of ill-defined punctures, separated by narrow lines of closely set, scaly bristles (somewhat as in *Colobicus parilis* Pasc., but more uniform). Underside subglabrous, opaque; prosternum asperate, margins with fine, transverse rugae, rest of underside smooth. Tibiae with short apical spines. Penultimate segment of abdomen about half as long as each of the preceding. *Dim.*—4 × 1.5 mm.

*Hab.*—Queensland: Tambourine Mt. (H. Pottinger).

There is no evidence of an 11th antennal segment. Holotype in the Queensland Museum.

*BUPALA FASCIATA*, n. sp. Plate ix, fig. 13.

Shortly oblong-ovate; head, except clypeus, and pronotum dull black. *Elytra* black with shoulder spot, postmedial fascia and an interrupted preapical fascia red, clypeus, underside and appendages red; upper surface clothed with white scaly bristles.

*Head* subquadrate, sides straight, surface with short white recumbent scale-like hair; antennae short, basal segment invisible from above, 10–11 of the typical form (i.e., 11th inconspicuous). *Prothorax* transverse, wider than usual, base roundly advanced in middle, all angles rounded off, sides nearly straight, the

marginal serrulations partly concealed by scaly hairs; base a little produced backwards; disk asperate, without evident punctures, subrecumbent hairs chiefly obvious on apical half. *Elytra* convex, ovate, slightly wider than prothorax at base; seriate-punctate, the seriate punctures large, the series separated by very narrowly raised lines on which are scale-like hairs, the scaly clothing more upright than on head and pronotum. *Dim.*—2 mm. long.

*Hab.*—N. S. Wales: Bogan River (J. Armstrong).

We have seen only one example of this little species. It is relatively wider than *dentata* Blkb., with an unmistakable colour pattern that should render it easy to recognize. Holotype in Coll. Carter.

*BUPALA VARIEGATA*, n. sp. Plate viii, fig. 10.

Shortly oblong-ovate; head and pronotum piceous, elytra piceous, largely variegated with testaceous; margins of prothorax, underside and appendages red; upper surface with white bristly hairs, more or less recumbent on head and thorax, forming series on elytral intervals.

*Head* subquadrate, clypeus rounded, eyes prominent, antennae short, basal segment unseen from above, 2 wider than 3, 3·9 small and close, 10–11 of typical form, 11 large and round. *Prothorax* transverse, base bisinuate, the medial area and anterior angles lightly advanced, the latter subacute; base widely produced backwards, posterior angles subrectangular, sides nearly straight, marginal serrulations emphasized by bristles, foliate margins scarcely defined; disk very lightly convex, scabrous and thickly clothed with bristles, save on a few denuded areas, as on two round depressions near base. *Elytra* slightly wider than prothorax at base, widest behind middle; seriate-punctate, the seriate punctures large and round, the series separated by thin lines bearing subrecumbent white scaly bristles. The testaceous markings occupying a considerable area, consisting of a large medial subquadrate patch sending off four oblique branches from its corners, to the shoulders and the apical declivity respectively and an arcuate subapical fascia. *Dim.*—2 mm. long.

*Hab.*—N. Queensland: Cairns district (A. M. Lea).

A single example in the South Australian Museum is similar in form to *B. fasciata*, but is quite distinctively patterned as above. Holotype in South Australian Museum.

The three Australian species of *Bupala* may be distinguished as follows:

- |   |                           |
|---|---------------------------|
| 1. Concolorous .....                                    | <i>australis</i> , n. sp. |
| More or less variegated .....                           | 2                         |
| 2. Black; elytral fasciae and humeral spot red .....    | <i>fasciata</i> , n. sp.  |
| Piceous; elytra widely variegated with testaceous ..... | <i>variegata</i> , n. sp. |

We do not know *B. pullata* Pasc. from Saylee, or *B. elongata* Grouv. from Sumatra.

*Note.*—The question of the generic distinction of *Bupala* from *Synchita* needs consideration, but in the absence of material of this Europeo-American group its discussion cannot be undertaken here.

*Bupala perforata* Blkb. = *B. dentata* Blkb. (Pl. ix, fig. 20; Text-fig. B).—This species cannot be retained in this genus, having the tarsal formula 3–3–3. Both were described from Adelaide and the same dimensions were given for both. Mr. Blair has taken much trouble in comparing examples with the types, which have been placed in the British Museum as synonymous. He writes: "though *dentata* is smaller, with the hairs of the elytra a little longer and the thorax slightly sinuate at the sides, I do not regard them as specifically distinct". We now propose the generic name *Pabula* for this. Since the Colydidae already contain

tri-tarsal forms (e.g., *Langelandia* and the New Zealand genus *Lithostygnus*), we consider that it is still a member of this family, the cephalic and antennal structure being obviously Colydiid.

PABULA, nov. gen. Synchitnorum (?).

Tarsal formula 3-3-3. Other distinctions from *Bupalus* Pasc.: (1) Head with postocular tooth, as noted by Blackburn in *B. dentata* only; (2) longer and more slender antennae; (3) narrower form, the prothorax widened at apex; (4) elytra with large, round, seriate punctures; sparsely pubescent.

*Bupalus bovilli* Blkb.—This also must be included under *Pabula*, since the tarsi are also 3-3-3. Mr. Blair has kindly sent an example from Port Darwin, compared with type. This was very dirty but, when cleaned, it showed an extremely close



Text-fig. B.—*Pabula dentata*: 1st, 2nd and 3rd tarsus drawn from micro-slide. Details of claw attachments and setae omitted.

likeness to *perforata* [so close indeed that Zeck stated that he would be unable to bring out any distinction in a drawing, except the absence of the small tooth behind the eye]. There is, however, a small pustule very close to the base. We note, also, slight differences in sculpture, the Port Darwin insect having the pustules of pronotum and of elytral intervals more obvious than the punctures, the reverse being the case in *perforata*. Until more material is available, *bovilli* may be considered as specifically distinct, as follows:

Head with small lateral tooth at base of eye .....	<i>perforata</i> Blkb.; <i>dentata</i> Blkb. (Pl. ix, fig. 20)
Head without lateral tooth .....	<i>bovilli</i> Blkb.

CEBIA Pasc.

We have not seen an authoritatively named example of this genus. A comparatively common species of wide distribution in Eastern Australia seems to correspond with the description of *C. scabrosa* Reitt. from Cape York. Dr. Walther Horn has very kindly attempted to track the elusive type of this, but so far in vain. It is not in the Stettin Museum or Berlin Museum. Another species from New Guinea, in the latter Museum, may be *C. rugosa* Pasc. The three species described here may be tabulated as follows:

- |   |                             |
|---|-----------------------------|
| 1. Colour black, elytra with red pattern .....  | <i>rufo-notata</i> , n. sp. |
| Colour fuscous .....                            | 2                           |
| 2. Elytra with about 10 subseriate tumuli ..... | <i>tumulosa</i> , n. sp.    |
| Elytra subuniformly granulose .....             | <i>communis</i> , n. sp.    |

*Eba cerylonoides* Pasc. = *Palorus exilis* Mars. (Tenebrionidae) = *P. minor* Waterh. (fide K. G. Blair).

*Pseudeba novica* Blkb. = *Palorus eutermiphilus* Lea (Tenebrionidae).—A cotype of *Pseudeba novica* Blkb. from the South Australian Museum exactly corresponds with a cotype of *Palorus eutermiphilus* Lea in Coll. Carter. (Curiously we had noted this synonymy before receiving Mr. Blair's note on *Eba*).

*CEBIA COMMUNIS*, n. sp.

Narrowly oblong; variably fuscous (often with reddish patches on the elytra), antennae and legs red.

*Head* subquadrate, granulose, clypeus arcuate, eyes not prominent, terminal segments of palpi oval; antennae: basal segment hidden from above, 1-2 wide, 3 longer than 4, 4-8 subequal, 9 larger than 8, 10-11 forming an abruptly widened club. *Prothorax*: base arcuately advanced in middle, anterior angles acutely produced, sides nearly straight, with a narrow foliation, widening in front, strongly fringed at border with scaly bristles, base lightly produced backward in middle, hind angles subrectangular, disk subdepressed, variably canaliculate, in general medial line lightly impressed throughout; rather closely scalose-granulose with pale, scaly bristles. *Elytra* of same width as prothorax at base, subparallel, striate-punctate, the punctures almost hidden by granulose, bristly clothing of the lightly-raised intervals, the coarser granules near suture giving the appearance of transverse rugae. Under-surface closely granulose, tibiae not evidently spined at apex. *Dim.*—3-5 mm. long.

*Hab.*—Eastern Australia, from N. Queensland to South Australia. Found in nearly all collections; 52 examples have been examined; Cairns (Lea), Brisbane (Hacker), Pine Mt. (Aust. Mus.), Tambourine Mt. (Lea), Clarence River (Lea), Wahroonga (Carter and Spence), Sydney (Lea), Illawarra (Carter), Victoria (Wilson and Blackburn), S. Australia (Macleay Mus.).

At first diagnosed as *Cebia scabrosa* Reitt. (described from "Cap York"), but certain discrepancies suggest distinction: (a) Absence of reference to strongly granulose prothorax; (b) "elytris . . . interstitiis angustis, subrugosis"; (c) "humeris lateribusque indeterminate dilutioribus"; (d) locality. With regard to (b) we have noted above "the appearance of transverse rugae". With regard to (c) we have noted "the occurrence of red patches". The wide distribution of the species discounts the value of locality. Thus there is an element of doubt, only to be cleared by comparison with type. Unfortunately it has been difficult to find the whereabouts of this. Our friend Dr. Horn writes that the type is not in the Stettin Museum or the Berlin Museum, "Where the type might be now is very doubtful as Reitter . . . sold his collections a dozen times".

*CEBIA TUMULOSA*, n. sp. Plate ix, fig. 16.

Oblong, convex; chocolate-brown, antennae, legs and oral organs red.

*Head* granulose and scabrous with scaly hair, clypeus subtruncate, sides very lightly raised and widened in front of eyes, these evident from above, medial region divided from the sublobate sides by sulci; antennae with two basal segments incrassate, 3-9 closely set, submoniliform, 10-11 forming a stout compact club. *Prothorax*: apex and base strongly bisinuate, both arcuately extended in the middle, front angles well advanced and acute, sides nearly straight, their extreme border fringed with scales, foliate margins continuous with and scarcely distinguished from disk; hind angles subrectangular, a little blunt at tips; disk everywhere scabrous and covered with bristly scaly clothing; medial line a variably wide and deep depression, not extending to basal or apical border, these both

defined by rather deep sulci. *Scutellum* triangular. *Elytra* of same width as prothorax, everywhere margined, like prothorax, with bristly scales, surface scabrous and uneven, through the symmetrically placed, low tumuli, sometimes ill-defined, but in general consisting of about ten, of which two are suural, the others more or less in two rows, surface also striate-punctate where discernible beneath clothing. *Underside* finely granulose, legs also fringed with fine scales, tibiae with short terminal spine, basal tarsi short. *Dim.*— $3\frac{1}{2}$ –4 mm. long.

*Hab.*—Victoria: Millgrove and Warburton (F. E. Wilson), Fernshaw and Dandenong Ranges (in Nat. Mus.). In tussocks or moss.

Ten examples, six taken by that keen observer, F. E. Wilson, differ from the species determined by us as *C. scabrosa* Reitt. in the slightly wider form, the even more roughly scabrous clothing, and the uneven surface of the elytra. Holotype in Coll. Wilson.

*CEBIA* (?) *RUFONOTATA*, n. sp.

Oblong; head and disk of pronotum opaque black, elytra black with red markings; foliate margins of prothorax, underside and appendages red.

*Head* subquadrate, clypeus rounded, sides straight, surface with recumbent white scaly hairs. Eyes prominent; antennae: basal segment hidden, 2 stout, 10–11 clavate, 11 smaller and narrower than 10. *Prothorax* very lightly bisinuate, medial region and angles feebly advanced, the latter subacute (blunt at tips); base widely but little produced, posterior angles subrectangular, sides nearly straight, foliate margins moderately wide, extreme border serrulate; disk convex, uniformly and densely granulose. *Elytra* rather wider than prothorax at base, sides nearly straight, a little divergent to behind middle; seriate-punctate, the seriate punctures moderately large and separated by light transverse ridges, the series separated by narrow longitudinal intervals; the red markings as follows: four equidistant, medial, patches—basal, medial, post-medial and apical; half-way between these and sides three more, humeral, premedial and postmedial; extreme border with line of short bristles. *Dim.*—2 mm. long.

*Hab.*—Swan River (Lea).

Two examples in the South Australian Museum must, we think, be referred to this genus. Holotype in the South Australian Museum.

*NEOTRICHUS ACANTITACOLLIS*, n. sp. Plate ix, fig. 15.

Elongate, parallel; opaque black, antennae dark red.

*Head* subquadrate, granulose, clypeus truncate, sides with a row of small blunt scales, terminating at the antennal orbits, and behind the eyes in triangular teeth, eyes prominent; antennae: basal segment hidden, 2 stout, 3–9 monilliform, 10–11 forming a compact club. *Prothorax*: apex irregularly produced over head and sub-bilobed from the extension of two divergent ridges, base rounded, sides widening from base to front angles, strongly so near front, margins denticulate with row of scales extending to the two anterior ridges, basal half with strong medial depression; general surface strongly granulate, transversely rugose near base. *Elytra* parallel, basal third depressed, more convex behind this; seriate-punctate, the intervals with rows of minute tubercles, becoming spicules on lateral outline. Tibiae also with serrulate edges. *Dim.*—3 mm. long.

*Hab.*—N. S. Wales: Springwood, Blue Mts. (A. Smith).

A narrow species with head and thorax suggestive of *Acantholophus* (Curculionidae). A single example given to us by Mr. J. Armstrong. Holotype in Coll. Carter.



## COLOBICUS Latr.

*Colobius parilis* Pasc.—This species has a wide dispersion in northern Australia. We have examples from Port Darwin, Cairns, Townsville and other parts of N. Queensland; also from Moa Island (Torres Str.) and Honolulu (Hawaï). Arrow records it from Damma Is., Ceram, Mysol, Timor, Lombok, Batakian, Borneo, Andaman Is., Penang, Assam and Hong Kong.

## ABLABUS Broun.

We have before us examples of all the recorded Australian species of this genus, to which three new species are added. An example of *Ditoma villosa* Lea has been compared with type and found to belong to this genus. The species may be tabulated as follows:

- |   |                                       |
|---|---------------------------------------|
| 1. Sides of prothorax entire .....                                    | <i>integricollis</i> , n. sp.         |
| Sides of prothorax otherwise .....                                    | 2                                     |
| 2. Sides of prothorax lobate .....                                    | 3                                     |
| Sides of prothorax spinose .....                                      | 5                                     |
| Sides of prothorax serrulate .....                                    | 6                                     |
| 3. Colour red with dark markings .....                                | 4.                                    |
| Colour black, sides of prothorax trilobate .....                      | <i>tuberculatus</i> , n. sp.          |
| 4. Sides of prothorax lobate anteriorly, posterior part serrate ..... | <i>pulcher</i> Blkb., Pl. ix, fig. 10 |
| Sides of prothorax bilobate, with medial tooth .....                  | <i>mimus</i> , n. sp.                 |
| 5. Sides trispinose, anterior spine sublobate; glabrous .....         | <i>blackburni</i> Group.              |
| Sides multispinose (about 9); surface pilose .....                    | <i>villosus</i> Lea                   |
| 6. Colour black; sides coarsely serrate .....                         | <i>obscurus</i> Blkb.                 |
| Colour red; sides very finely serrulate .....                         | <i>niticola</i> Blkb.                 |

## ABLABUS INTEGRI-COLLIS, n. sp. Plate ix, fig. 21.

Ovate, convex; dark brown, appendages red.

*Head*: clypeus arcuate, sides with wide triangular lobe, slightly obliquely raised, in front of eyes; surface minutely granulose, eyes round and prominent; antennae with basal segments narrower than usual, 3-9 moniliform, 9 larger than 8, 10-11 forming a stout club. *Prothorax*: apex strongly advanced in middle and slightly raised over head, angles strongly advanced and acute, widest near base, sides widely rounded, foliate margins wide, border entire, hind angles quite rounded off; base less strongly bisinuate than usual. Disk raised by two undulate ridges, irregularly narrowed towards apex and base and forming an oval depression in middle, and a smaller oval at base, divided from medial oval by transverse ridge. Whole surface finely granulose. *Scutellum* transversely triangular. *Elytra* as wide as prothorax at its widest, ovate, with narrow horizontal margin, considerably widened at shoulders and at apex, apices separately rounded; disk with three rows of elongate nodules, the exterior of these consisting of two, the two inner ones with about three in each, besides smaller tubercles at apex; whole surface with series of larger granules and some undefined punctures. *Dim.*—4 mm. long.

*Hab.*—Tasmania: Hobart (in British Museum).

A single example is amongst those sent for examination. Holotype in the British Museum of Natural History.

## ABLABUS MIMUS, n. sp. Plate ix, fig. 17.

Short, ovate, convex; red, base of head black.

*Head* widened in front of eyes, clypeus arcuate, forehead bipustulate, surface sparsely clad with short white hair; antennae: basal segment hidden, 2 stout, 3-9 small and close, 10-11 forming a stout club. *Prothorax* very uneven and convex, medial part of apex sub-bilobed through the extension of discal crest,

front angles well advanced, foliate margins in three parts, (1) a wide anterior, securiform lobe, its border lightly triramose, (2) a medial triangular tooth, (3) a short, narrow, posterior area with serrate border and a small rectangular hind angle; the raised disk chiefly consisting of a medial depression bounded by undulate ridges, these meeting near base and again diverging to form a small triangle at base; surface finely granulose and sparsely pubescent. *Elytra* considerably wider than prothorax at base, margins strongly serrate, apices divergent and sharply angulate; disk convex (concealing narrow margin, except near apex), with ridges and tubercles. Of the former the more prominent enclose a pentagonal area at base; small ridges at shoulders; of the tubercles, four elongate ones on the 2nd interval, two at middle and two on apical declivity; exterior to these about eight conical tubercles in alternating rows of four. General surface with series of large, round punctures. *Dim.*—2-2½ mm. long.

*Hab.*—N. Queensland: Cairns (Ferguson Coll., Canberra Museum).

Two carded examples form a curious mimic of *A. pulcher* Blkb. The chief distinctions are: (1) size much smaller—about half as long, (2) foliate margins with anterior lobe itself triramose at margin—entire in *A. pulcher*, (3) discal ridges of pronotum, also ridges and pustules of elytra, similar in pattern but much more strongly raised and occupying a relatively greater area than in *A. pulcher*. Holotype in Canberra Museum.

*ANILABUS TUBERCULATUS*, n. sp. Plate ix, fig. 18.

Oval, convex; subnitid black, the tarsi red, a fringe of white hair at apex of prosternum and along femora, elytral tubercles capped with reddish hair.

*Head*: clypeus rounded, hollowed within, sides widened and raised into a lobe in front of eyes, two nodules near base, eyes round and prominent, surface strongly granulose; antennal segments 1-2 very stout, 3-9 submoniliform, 3 rather longer than 4, 9 larger than 8, 10-11 forming a stout club. *Prothorax*: apex with medial lobe advanced and strongly raised, with a slightly undulate outline, angles also strongly advanced and acute, foliate sides trilobate, the first largest, hatchet-shaped, the medial widely rounded with a horizontal base, the third lobe (much the smallest) forming a wide triangular hind angle; base with medial lobe widely rounded and produced backward. Disk strongly raised by two undulate ridges, starting from the anterior lobe, rising to a tubercle midway, thence narrowing and meeting near base to bifurcate again, forming a small triangle at base; medial area depressed, forming an oval between tubercles and front lobe; whole surface coarsely granulose. *Scutellum* subcircular. *Elytra* as wide as prothorax at its widest (the middle); ovate, very convex, each with three strong tubercles near base, the humeral and the innermost of these forming short ridges to the basal border, the middle one smaller and conical; these generally capped with a tuft of short, reddish hair; the rest of elytra with three rows of large tubercles (here and there showing traces of the hairy cap), the inner two rows containing three each, the exterior (forming the margin as seen from above—the real margin hidden) containing six at least, smaller tubercles on apical declivity; interspaces with closely-set, rounded, large granules. *Underside* finely granulose, tibiae with a short terminal spine, tarsal segments short and subequal. *Dim.*—3-4 mm. long.

*Hab.*—Tasmania: Frankford and Wilmot (A. M. Lea).

Six examples in the South Australian Museum show a very distinct member of the genus, both by its sombre colour and striking sculpture. Holotype in the S. Australian Museum.

## ORTHOGERINI.

ORTHOGERUS Latr. (*Sarrotrium* Ill.).

*O. (Sarrotrium) australis* Bk. is the only known Australian species of this genus. Four examples have been examined—three from the South Australian Museum, labelled Hobart and Forest Reefs, N.S.W. (Lea), N.S.W. (in Blackburn's handwriting, probably co-type), and one in the National Museum, from Mt. Wilson, N.S.W. (Carter). The "bright red" fascia, noted by the author, fades to a dull, inconspicuous brown. It is fantastically like *Latometus pubescens* Er. (*Elasmus crassicornis* Pasc.), so that a close examination of the tarsi is necessary to distinguish them, though there is also a slight difference of elytral sculpture. This similarity is carried even to the post-ocular tooth of the pronotum.

EPISTRANUS TIBIALIS, n. sp. Plate ix, fig. 22.

Oval, very convex; subnitid black, depressed areas brown.

*Head*: labrum prominent, clypeus subtruncate (lightly incurved at middle), hinder half of head with wide lateral lobe, partly concealing eyes, surface roughly granulate; antennae rather long, segment 1 very wide, 2 elongate, piriform, 3 intermediate in size between 2 and 4, 4-9 subequal moniliform, 10-11 forming a loose club. *Prothorax* very wide and convex, apex with strongly raised medial lobe produced over head, its margins serrate and ciliate, the widely arched and serrated foliate margins on a lower plane, anterior angles dentate, sides sinuate near base, their border ciliate, posterior angles obtuse, base with discal part produced backwards. Disk with two prominent ridges throughout, formed by rows of close pustules, the ridges diverging anteriorly, a second and sinuate row of pustules forming external ridge of discal area. *Scutellum* wanting. *Elytra* strongly convex, little longer than combined head and thorax, and as wide as the latter, extreme border coarsely serrate, each tooth with a single scale-like cilia; each with four irregular rows of rounded pustules, the sutural rows diverging at base and terminating in larger pustules, corresponding with prothoracic ridges, a second larger pair of pustules terminating the 3rd row; whole surface coarsely rugose-punctate, with many large foveate punctures. All tibiae ciliate, with wide triangular lobe on external edges and fitted with grooves for reception of tarsi; without apical spur. *Underside* remarkable for raised medial area of head, prosternum and intercoxal region, leaving deep lateral hollows. On head a deep antennal groove, the wide lateral hollow of prosternum receiving the apical part of antennae and the anterior legs, intermediate and post tibiae similarly received into hollows behind coxae. All coxae rather widely separated, the post coxae more widely than the others. Front coxae closed. Apical segment of palpi elongate-ovate, mentum transverse, subrectangular, with rounded angles. *Dim.*— $4 \times 1\frac{1}{2}$  mm.

*Hab.*—Victoria: Lakes Entrance (F. E. Wilson).

A single ♂ (aedeagus exposed) of this remarkable insect was taken by sifting leaf refuse. It follows closely Broun's diagnosis of *Epistranus*, a genus placed under Coxelini, which is scarcely consistent with Grouvelle's tabulation of that group "cavités des hanches antérieures en partie ouvertes" (*Soc. Ent. Fr.*, 1908, p. 398). Holotype in Coll. Wilson.

*Note.*—No mention of a scutellum occurs in Sharp's generic diagnosis, nor in the descriptions of the five New Zealand species in Broun's excellent manual.

## PYNOMERINI.

We have followed Pascoe in placing the species with 11-segmented antennae under *Penthellspa*. Possibly Blackburn was technically correct in stating that

these formed the 1st group of Erichson's genus. Yet the distinction deserves a special name, and time and custom are in favour of this retention of *Penthellispa* for the known Australian species. Of the nine names only four, we think, will stand, i.e., *fuliginosa* Er., *interstitialis* Blkb., *blackburni* Hetschko, and *secuta* Pasc. We do not know the second of these; the other three may be tabulated thus:

*Table of Penthellispa Pasc.*

- |   |                           |
|---|---------------------------|
| 1. Surface opaque .....                                 | 2                         |
| Surface nitid .....                                     | <i>secuta</i> Pasc.       |
| 2. Elytral intervals flat and clearly punctate .....    | <i>fuliginosa</i> Er.     |
| Elytral intervals convex and not clearly punctate ..... | <i>blackburni</i> Hetsch. |

Synonymy:

*P. fuliginosa* Er. = *obscura* Pasc. = *robusticollis* Blkb. (fide K. G. Blair).

*P. blackburni* Hetsch. = *sulcicollis* Blkb. (nom. praecoc.).

*P. secuta* Pasc. = *polita* Lea = *picea* Lea.

*P. secuta* is very widely distributed and variable in size and colour. *P. robusticollis* Blkb. alone of the Australian species has been freakishly placed under *Pycnomerus* in the Junk Catalogue.

*Gemphylodes tinctus* Oll. (misspelt 'tinctus' in the Junk Catalogue), described from Lord Howe Island, is not rare on the mainland of Australia. [I have an example from Dorrigo, N.S.W., and another from Millaa Millaa, N. Queensland.—H.J.C.]

*Todima* Grouv.—The four species recorded are before us and may be tabulated as follows:

- |  |                          |
|--|--------------------------|
| 1. Prothorax widened anteriorly .....                                  | <i>fulvicincta</i> Elst. |
| Prothorax not widened anteriorly .....                                 | 2                        |
| 2. Upper surface concolorous (dark) .....                              | <i>fusca</i> Grouv.      |
| Upper surface bicolorous .....   | 3                        |
| 3. Sides of prothorax and elytra yellow, seriate punctures small ..... | <i>lateralis</i> Blkb.   |
| Elytra variably yellow, seriate punctures large .....                  | <i>rufula</i> Grouv.     |

But for the striking difference in the size of the seriate punctures, at least in the medial area, the last two species might be confused, since the colour seems variable. My examples are localized as follows: *fulvicincta* Elst. (Mt. Remarkable, South Australia), *fusca* Grouv. (Allyn River, N.S.W., and Mt. Barker, W.A.), *lateralis* Blkb. (Mypunga and other parts of S. Aust., Macleay River, N.S.W.), *rufula* Grouv. (Beverley, W.A., and N. Queensland).

*Meryrx* Latr.—The two species of this genus are so well known as to need little comment, with the synonymy:

*M. rugosa* Latr. = *arcolata* (*Rhyssopera*) Pasc. = *illota* (*Rhyssopera*) Pasc.

DERETAPHIRUS NEWMI.

The insects of this genus are moderately common, very widely distributed over the continent, variable in size, and in colour from immaturity. It has been difficult to initiate a clear tabulation of the genus since the genotype, *D. fossus* Newm., is apparently missing. Of *D. fossus* Mr. K. G. Blair writes as follows:

"An example determined by C. O. Waterhouse, compared with the common *D. ignarus* Pasc., has the pronotum more cordiform, with the anterior angle clearly seen from above, the pronotal sulcus broader, almost double (wedge-shaped), elytra with 1st and 2nd intervals flat, 3rd feebly carinate (rather a row of shining points than a carina, except at apex), 4th flat, 5th carinate, 6th traces of a carina near base and beyond middle, 7th carinate. *D. ignarus* Pasc. has the elytra dull, with all intervals, except 1st and 2nd, more or less carinate, 4th and 6th less so and obsolete behind. The example determined as *fossus* Newm. corresponds with Blackburn's type of *cordicollis*."

An example, labelled '*fossus*' by Blackburn in the South Australian Museum, is clearly *ignarus* Pasc.

*D. erichsoni* Newm. and *D. piceus* Germ. are easily recognized, the former by its cylindric form and ill-defined pronotal sulcus, the latter by its fine pronotal sculpture.

In 1862 Pascoe described *bakewelli*, *colydioides*, *ignarus* and *viduatus*.

*bakewelli* = *piceus* Germ.—Pascoe himself only distinguished these in his table by colour and size.

*colydioides* Pasc. is probably a small *viduatus* Pasc. The other two are well known and widely distributed. *D. pascoi* MacL. is clearly identical with *ignarus* Pasc.

In 1898, Lea described *analis*, *parviceps*, *puncticollis* and *xanthorrhoeae*. We have not been able to identify *parviceps* from Western Australia. The other three are quite distinct: *analis* by its large size, nitid and scarcely punctate pronotum (found at Dorriggo, Queensland National Park and Southern Queensland); *puncticollis* is rare in collections, from the interior of New South Wales and South Australia. Its pronotum is crowded with coarse punctures, its sulcus only vaguely defined; *xanthorrhoeae* Lea is from Western Australia, with a pronotal sculpture intermediate between that of *piceus* Germ. and *ignarus* (nearer the former than the latter).

In 1903, Blackburn described eight species, *aequaliceps*, *cordicollis*, *cribriceps*, *gracilis*, *iridescens*, *popularis*, *sparsiceps* and *thoracicus*, the types being in the British Museum: *cordicollis* = *fossus* Newm. (as above); *thoracicus* = *piceus* Germ.; *sparsiceps* = ? *viduatus* Pasc.

[I have hypothetically identified *aequaliceps* and *cribriceps* and have satisfactorily verified *gracilis* and *popularis*. My example of *popularis* (compared with type) came from Roma, Q. In the description the author says, "not sure of exact habitat".—H.J.C.]

There is a cotype of *sparsiceps* among those sent from the South Australian Museum. It is not in good condition, but seems indistinguishable from *viduatus* Pasc. Mr. Elston has courteously sent his type of *D. bucculentus* for examination. It is identical with *puncticollis* Lea, of which an example is in the Ferguson collection at Canberra, with the name label in Lea's well-known handwriting. The two descriptions by Lea and Elston respectively are almost identical in essential characters. Descriptions of two new species are appended.

Table of *Deretaphrus* Newm.

1. Pronotum without medial sulcus .....	<i>incultus</i> , n. sp.
Pronotum with vaguely defined sulcus .....	2
Pronotum with well defined sulcus .....	3
2. Form cylindric, elytral costae granulose .....	<i>erichsoni</i> Newm.
Form explanate, elytral costae entire .....	<i>puncticollis</i> Lea
3. Pronotal sculpture very fine .....	4
Pronotal sculpture moderately fine .....	5
Pronotal sculpture coarse .....	6
4. Elytral intervals rounded, not carinate .....	<i>analis</i> Lea
Third and fifth intervals carinate .....	<i>piceus</i> Germ.
5. Elytral intervals 3, 4, 5, more or less carinate .....	<i>xanthorrhoeae</i> Lea
Elytral intervals 3, 4, 5, flat or nearly so .....	<i>gracilis</i> Bkbl.
6. Pronotal punctures contiguous (alveolate) .....	<i>alveolatus</i> , n. sp.
Pronotal punctures not contiguous .....	7
7. Elytra each with, at least, 3 well-raised carinae .....	8
Elytra each with 4 interior intervals flat, or nearly so .....	9
8. Anterior angles of pronotum well defined .....	<i>fossus</i> Newm.
Anterior angles of pronotum rounded off and depressed .....	<i>ignarus</i> Pasc.

9. Head impressed or sulcate ..... 10  
 Head evenly convex ..... 11  
 10. Clypeus longitudinally sulcate ..... *viduatus* Pasc.  
 Clypeus impressed ..... *popularis* Blkb.  
 11. Anterior angles of prothorax defined ..... *aequaliceps* Blkb.  
 Anterior angles of prothorax rounded off ..... *cribriceps* Blkb.

Not included in table, *parviceps* Lea.

*Synonymy*.—*D. fossus* Newm. = *cordicollis* Blkb.

*D. piceus* Germ. = *bakewelli* Pasc. = *thoracicus* Blkb.

*D. viduatus* Pasc. = *colydioides* Pasc. = *sparsiceps* Blkb.

*D. ignarus* Pasc. = *pascoei* Macl.

*D. puncticollis* Lea = *bucculentus* Elst.

*D. gracilis* Blkb. = *iridescent* Blkb.

#### DERETAPHRUS ALVEOLATUS, n. sp.

Elongate, subcylindric; head subnitid, pronotum and elytra opaque black, antennae, legs and underside red.

*Head*: clypeus rounded, its outline entire, closely punctate on forehead, more sparsely and finely on epistoma, eyes clearly evident from above, antennae unusually stout, segment 1 bulbous, 2 beadlike, 3-8 closely set, 9-11 strongly transverse, 9 and 10 wider than 11. *Prothorax* longer than wide ( $2 \times 1.6$  mm.) anterior angles depressed and rounded off, sides lightly narrowed to basal third, here feebly sinuate and subparallel to the widely obtuse hind angle, base arcuately produced behind; whole surface alveolate-punctate, with rather small cell-like punctures closely fitted together, here and there confluent, a medial elongate area lightly flattened, a short, wide, shallow sulcus near base. *Scutellum* circular. *Elytra* cylindric, as wide as prothorax at its widest and  $2\frac{1}{2}$  times its length, striate-punctate, seriate punctures small and close near suture, larger and more distant elsewhere, two sutural intervals depressed and almost imperceptibly punctate, 3-7 finely carinate and impunctate, the carinae more marked at base and apex. *Dim.*— $8 \times 1.6$  mm.

*Hab.*—Western Australia: Cue (H. W. Brown).

A single example is among the Colydiidae sent from the South Australian Museum and is so distinct as to be worth naming, the delicate reticulation of the pronotum being in strong contrast with the coarse, close punctures of *D. puncticollis* Lea. Holotype in the South Australian Museum.

#### DERETAPHRUS INOULTUS, n. sp.

Depressed; black, elytra brown.

*Head* coarsely punctate. *Prothorax* subcordate, rather flat, anterior angles widely obtuse and vaguely defined, sides narrowed from apex to base, only slightly sinuate behind, base lightly excised near angles, these obtuse, with a minute tooth pointing outwards. Disk rather closely and coarsely punctate, without a sign of medial sulcus; the punctures more sparse towards the centro-basal area, dense towards sides. *Elytra* wider than prothorax at base, epipleural fold forming a light dentate ridge at humeri; strongly striate-punctate, the striae punctures close and round, intervals lightly convex and clearly punctulate; 3rd, 5th and 7th finely carinate. Underside coarsely and closely punctate; abdomen rather less coarsely than the rest. *Dim.*— $8 \times 2$  mm.

*Hab.*—Western Australia: Coolgardie and Beverley (Du Boulay and H.J.C.), also Kellerberrin (in the S. Aust. Museum).

Four examples examined are very distinct from all described species by their entirely non-sulcate prothorax. *D. erichsoni* Newm. most nearly approaches in

this respect, but is very convex, with a characteristic elytral sculpture with granulate intervals and quite different seriate punctures. Holotype in Coll. Carter.

#### OXYLAEMUS Er.

*Oxylaemus leae* Grouv.—An example of this cylindric species is in the collection of F. E. Wilson from Warburton, Victoria. It was described from Tasmania.

#### METOPISTES STRIGICOLLIS, n. sp. Plate ix, fig. 24.

Subcylindric; subopaque, dark chestnut-brown, antennae and tarsi red.

*Head* slightly concave, finely and densely punctate, with short red pubescence; antennae rather short, two basal segments tumid, biclavate, 10–11 forming a large round club. *Prothorax* ovate, apex arcuately advanced in middle, rounded and recessed at sides, all angles widely rounded off, base truncate, sides a little sinuately narrowed behind; disk with fine longitudinal strigae, coarser near middle, finer near sides. *Scutellum* ovate. *Elytra* wider than prothorax, sides parallel, each with three well-raised carinae, the lateral and sutural margins also, but more narrowly, carinate; the depressed intervals with irregular rows (about 3) of round punctures; *underside* glabrous, closely punctate. *Tibiae* widened at apex, *post-tarsi* with 1st segment nearly as long as the rest combined. *Dim.*—4½ mm. long.

*Hab.*—N. S. Wales: Sydney (Macleay Museum).

A single example in the Macleay Collection, labelled as above, is clearly separated from Pascoe's three species, *M. tubulus* Shp. and *M. indicus* Grouv. by the sculpture of the pronotum, which is nowhere punctate. Holotype in the Macleay Museum.

#### BOTHRIDERES Er.

The insects of this genus are amongst the commonest of Australian Coleoptera, subject to extreme variation in size and colour. This has led to great redundancy in nomenclature, though much of this could have been obviated by a more careful identification by later authors of the earlier recorded species. Twenty-three names occur, for which we can find only seven distinct species. The genus is also widely found in Africa, America, Ceylon, New Guinea, Philippines, Formosa, New Zealand and New Caledonia, one species occurring in Spain and the south of France.

In 1842 Newman described *illusus*, *puteus* and *vittatus*. Lea seems to have known *vittatus*, but both Macleay and Lea redescribed *puteus* as *rectangularis* and *opacus* respectively. Blackburn explicitly states, "I am not acquainted with *B. illusus* Newm.", while three of his four species are, we consider, repetitions of Newman's and Pascoe's species, e.g., an example of *variabilis* Blkb., labelled cotype, in the South Australian Museum is identical with one sent from the British Museum as *illusus* Newm. The identity of *B. anaglypticus* Germ. with *puteus* Newm. is clear from its description, and not, as Lea suggested, with *mastersi* MacL. The words "conferatim et pro parte rugoso-punctatus" of the thorax and "opaca" of the elytra cannot apply to *mastersi*, but do apply to *puteus*.

With regard to Pascoe's species, Arrow (*Ann. Mag. Nat. Hist.*, 1909) has already pointed out that four of these are redundant or mere variations. We consider further that *taeniatum* Pasc. is a variety of *equinus* Pasc., only separated in his table by colour.

Macleay's two names, *pascoei* and *kreffti*, again represent slightly different forms of the same common species, while a cotype of *intermedius* Lea is a typical *equinus* Pasc.

*B. illusus* Newm., *lobatus* Pasc. and *tibialis* Blkb. have been very difficult to clarify by constant characters. After an exhaustive examination of long series, our conclusions lead us to consider these three names as of two distinct species characterized as follows:

*illusus* Newm.

*Dim.*—5–7 mm. long.

*Colour.*—Opaque brown.

*Prothorax.*—Margins with wide, but distinct angulation at middle, disk with coarse, subconfluent punctures longitudinally rugose in places.

A smooth medial line connecting a vague premedial depression with a small fovea near base, 2 short subcostate impressions behind this fovea.

*Elytral* intervals 3, 5, 7 sharply costate, 2, 4 flat, not visibly punctate.

*Front tibiae* longer, little widened at apex.

*Prosternum* moderately punctate.

*lobatus* Pasc.; *tibialis* Blkb.

*Dim.*—2–5½ mm. long.

*Colour.*—Subnitid, piceous to red.

*Prothorax.*—Margins generally without, or with vague angulation, disk with finer longitudinal system of punctures.

No smooth line; premedial and post-medial depressions superficial, sometimes obsolete; no prebasal costae.

*Elytral* interval 3 feebly raised, 5, 7 costate. All intervals clearly punctate.

*Front tibiae* shorter, strongly widened at apex.

*Prosternum* densely, subconfluently punctate.

*B. ustulatus* Lea is a good species found widely in the interior of New South Wales and Victoria as well as in Western Australia.

A single example sent from the British Museum, bearing a locality label 'Champion Bay' and a MS. name by Pascoe appears to be an undescribed species. Its characters suggest a relation with *B. bifossatus* Grouv. from New Caledonia. We think it is well to withhold this from publication until further material can be examined and its separation from Grouvelle's species maintained. The Australian species may be thus tabulated:

*Bothrideres* Er.

- |   |                       |
|---|-----------------------|
| 1. Pronotum with a single elongate depression .....                             | 2                     |
| Pronotum otherwise .....  | 3                     |
| 2. Opaque brown, prothorax coarsely punctate .....                              | <i>putcus</i> Newm.   |
| Nitid reddish, prothorax finely punctate .....                                  | <i>masteri</i> MacL.  |
| 3. Prothorax convex .....   | 4                     |
| Prothorax flat .....  | 6                     |
| 4. Sides of prothorax angulate, disk coarsely rugose-punctate .....             | <i>illusus</i> Newm.  |
| Sides of prothorax not, or vaguely angulate, discal punctures less coarse ..... | 5                     |
| 5. Pronotal sculpture longitudinal, front tibiae much widened .....             | <i>lobatus</i> Pasc.  |
| Pronotal sculpture not longitudinal, tibiae normal .....                        | <i>ustulatus</i> Lea  |
| 6. Elytra reddish or vittate, prothoracic margins angulate .....                | <i>vittatus</i> Newm. |
| Elytra opaque brown, prothoracic margins not angulate .....                     | <i>equinus</i> Pasc.  |

*Synonymy.*—*B. putcus* Newm. = *anaglypticus* Germ. = *rectangularis* MacL.  
= *opacus* Lea.

*B. illusus* Newm. = *variabilis* Blkb.

*B. vittatus* Newm. = *suturalis* MacL. = *merus* Pasc. = *musivus* Pasc.  
= *costatus* Blkb. = *victoriensis* Blkb.

*B. equinus* Pasc. = *taeniatus* Pasc. = *pascoei* MacL. = *kreffti* MacL.  
= *intermedius* Lea.

*B. lobatus* Pasc. = *servus* Pasc. = *versutus* Pasc. = *tibialis* Blkb.  
= *aberrans* Lea.

*N.B.*—The variation in size is well exemplified in *B. vittatus* Newm. Examples before us vary from 6 mm. to 2 mm. long.



*Machlotes (Erotylathris) costatus* Shp.—An example of this Japanese insect, labelled 'Queensland', was among the British Museum Colydiidae sent. Other examples are in the Macleay and South Australian Museums, both from Cairns. From their descriptions it is difficult to separate this from *Machlotes porcatus* Pasc. from Penang, but the testimony of both Sharp and Grouvelle stand to the contrary.

"*Erotylathris costatus* Shp. is a *Machlotes*, very near *porcatus* Pasc., but differs in its somewhat more elongate form and more closely punctured elytral series; in *porcatus* there are about 9 in the anterior half of the 2nd interval, whereas *costatus* has about 12. Sharp appears to have misunderstood *Erotylathris* when putting his species into it—he was obviously uncertain about it." (Note by Mr. K. G. Blair.)

*Leptoglyphus forcifrons* Grouv. is another of the British Museum specimens examined. This bears the label 'Port Darwin', while another example carries labels 'cotype' and 'Nilgiri Hills, India'.

*Dastarcus* Walk. (= *Pathodermus* Fairm.)—There appears to be little doubt as to the synonymy of *D. decorus* Reitt. = *D. (Pathodermus) rufosquameus* Fairm., a common species in N. Queensland, also found in New Guinea and Malacca.

*D. confinis* Pasc. is chiefly distinguished from the former by its much smaller size (9 mm. instead of 14 mm. long).

Two examples in the Macleay Museum, from Hall Sound, New Guinea, are probably *D. vetustus* Pasc. and *D. pusillus* Pasc., respectively 7 mm. and 4½ mm. long; the latter distinguished, as the author states, by its "peaked" elytra. We have not enough material to attempt a tabulation; moreover, the scales and fascicles on the upper surface of these insects are readily abraded, so that worn examples present a very different aspect from fresh ones.

#### CERYLON LATR.

Only one species, *C. alienigenum* Blkb., has, so far, been described from Australia. The description is largely a comparison with a European species, *C. ferrugineum* Steph.—a method very unhelpful to Australian students. Moreover, a mistaken determination has occurred in an example sent from the South Australian Museum, labelled *C. alienigenum* Blkb. [not, I think, in Blackburn's handwriting—H.J.C.]. This example is clearly *Ochollssa nigricollis* Grouv., as figured by that author. Mr. Blair has now courteously sent an example of *C. ferrugineum* Steph., which enables us to determine, with a query, *C. alienigenum* Blkb. for a species taken by one of us at Otford, and by Lea at Richmond River, N.S.W., and possibly some half-dozen examples taken by Lea at Tambourine Mountain, S. Queensland. It must be a close ally of *C. tibialis* Shp. and *C. pusillum* Pasc.

The following tabulation, at least, separates the 5 species before us. *C. humeridens* Grouv. is hypothetically determined from description. This seems a better course than adding further to a possible synonymy, the distribution of small Colydiidae making such determination possibly correct.

#### Cerylon Latr.

1. Colour black .....	<i>nigrescens</i> , n. sp.
Colour red .....	2
2. More or less pilose .....	3
Glabrous .....	4
3. Form ovate, hairs long .....	<i>longipilis</i> , n. sp.
Form oblong, finely pilose .....	? <i>humeridens</i> Grouv.
4. Form oblong-ovate, elytra widest at middle .....	<i>parviceps</i> , n. sp.
Form oblong, subparallel .....	? <i>alienigenum</i> Blkb.

*Philothermus* Aube.—Two species of this genus are before us. Of these, 12 examples from Tasmania (A. M. Lea) exactly correspond with 4 examples sent from the British Museum. Of these four, two are labelled 'Picton, New Zealand, taken by Helms', with the name-label '*Philothermus nitidus* Shrp'. The other two, labelled 'Hobart', are, we consider, identical with the New Zealand examples. This is an interesting fact of distribution, the insects common to Australia and New Zealand being few.

A single specimen of a *Philothermus* from Glen Innes, N.S.W., also taken by Lea, has been hypothetically determined as *P. sanguineus* Broun. from description.

For the sake of Australian collectors a few details are given of these two species.

*P. nitidus* Shrp.—Oblong-navicular, elytra sharply narrowed behind. Form rather wide, elytra irregularly striate-punctate, antennal club, 10th cup-shaped, 11th ovoid; 2-2½ mm. long.

? *P. sanguineus* Broun.—Narrowly oblong, elytra deeply striate, with half-concealed punctures, antennal club with 11 little larger than 10; 1½ mm. long.

Both species are of a deep-red colour, the pronotum coarsely, sparsely punctate.

*Euxestinae*.—This group is included in the Colydiidae by Hetschko (Junk Cat.). The late A. M. Lea considered *Euxestus* as belonging to the Erotylidae. We have had no opportunity of studying his types and omit this group from discussion.

*Ocholissa* Pasc.—We have mentioned above the example sent as *Cerylon alienigenum* Blkb. Numerous examples from Cairns are in the various collections examined. The majority of these are clearly *O. humeralis* Fairm., but a few have the elytra wholly black, without the yellow shoulder spot. This is apparently the variety *atra* Grouv. A few others (including the mis-labelled example) have the elytra more or less wholly pale, which is, almost certainly, the form named *O. nigricollis* Grouv. We think, therefore, the following synonymy is established: *O. humeralis* Frm.: Var. 1. *atra* Grouv.; Var. 2. *nigricollis* Grouv. The distribution, given in Junk, is Madagascar, E. Africa, E. Indies, Ceylon, Borneo, Batchian, Tahiti; to which North Australia must now be added.

*Ocholissa lei* Grouv.—Three examples are in the Lea Coll. from Mt. Wellington, Tasmania, also one labelled Sydney, N.S.W.

#### CERYLON LONGIPILIS, n. sp. Plate ix, fig. 14.

Short, ovate; nitid dark red, antennae and legs pale red, antennal club testaceous.

*Head* with a few large distant punctures, eyes large and prominent, antennal basal segment very tumid, about twice as long as 2, 2 and 3 subequal, each longer than 4, 4-8 small and closely set, 9 larger than 8, 10-11 forming a large ovoid club, strongly pubescent and elongate towards apex. *Prothorax* strongly transverse, apex arcuate, front angles advanced but obtusely blunted; base subtruncate, its angles sharply rectangular, sides lightly rounded, arcuately narrowed in front, horizontal margin narrow, its border entire; disk very coarsely, sparsely and rather irregularly punctate, without sign of medial line, basal foveae large and deep. *Scutellum* large, triangular, with one or two punctures. *Elytra* rather convex and oval, of same width as prothorax at base, humeri with a small projection; striate-punctate, the striae shallow, the punctures coarse and irregular in size, intervals in places subconvex, with a single line of fine punctures, with

sparse, pale, upright hairs much longer than on prothorax. Underside everywhere coarsely punctate. Tibiae strongly and roundly widened. *Dim.*—1½ mm. long.

*Hab.*—S. Queensland: Tambourine Mountain (A. M. Lea).

Three examples—or more correctly 2½, since one example is only represented by the hinder half—are under examination. One of these is probably immature, being pale yellow in colour. On a visit to the above district in 1914, Lea did a good deal of sifting leaf refuse, in which these insects occur. It differs from other species seen by us in the sparse, long hairs of the upper surface, the coarse, not close punctures and the dentate humeri. It must be near *C. setulosum* Champ. (from Assam), and *C. humeridens* Grouv. (from India). The following details in their respective descriptions point to distinction: "antennae 10–11 fused into a larve oval club . . . prothorax closely punctate . . . smooth medial line" of the former species and "prothorace . . . disco basin versus utrinque subimpresso . . . elytra . . . suturo basin versus recesso" in the latter. In each case only a single example is known, so that the possibility of synonymy of all three species cannot be dismissed. Holotype in the South Australian Museum.

*N.B.*—A single example from Cairns (N.Q.) before us must be still closer to *C. humeridens* Grouv., so that at present it cannot be described as distinct. It differs clearly from *C. longipilis* by flatter form, shorter pilosity, and the more regularly and deeply striate-punctate elytra.

*CERYLON NIGRESCENS*, n. sp.

Subconvex, oblong; subnitid black above, the narrow margin of pronotum and elytra, underside and appendages red.

*Head*: Clypeus rounded, eyes prominent, surface densely and finely punctate; antennae: segment 1 stout, 2 globose (beadlike), 3 twice as long as 4, 4–8 small and close, 9 larger than 8, 10 clavate and oval. *Prothorax* subquadrate, slightly widest near front, apex arcuate, anterior angles advanced but rounded, base very lightly bisinuate, sides nearly straight, arcuately narrowed in front, a narrow sulcate margin; disk rather depressed, closely, rather finely punctate, a feeble suggestion of a smooth medial line behind middle; without basal foveae. *Scutellum* transversely oval. *Elytra* of same width as prothorax at base, sides subparallel for the greater part, bluntly rounded at apex; striate-punctate, the striae well impressed, except at extreme apex, the punctures therein close, regular and of moderate size; intervals flat, each with a single row of minute punctures. Underside finely and sparsely punctate. *Femora* stout, *tibiae* little widened. *Dim.*—2½ mm. (approx.) long.

*Hab.*—Queensland National Park.

Two examples, sent by Mr. Hacker of the Queensland Museum, differ from all Australian *Cerylon* spp. seen, by the dark upper surface, the fine, close punctures of thorax and its straight, oblong form. We cannot make out any dentation of the humeri, the thorax being closely applied to the elytra along its whole width. Holotype in the Queensland Museum.

*CERYLON PARVICEPS*, n. sp. Plate ix, fig. 23.

Oblong-ovate; castaneous, very nitid and glabrous.

*Head* unusually small, straight-sided, but for the prominent eyes, clypeus lightly arcuate, finely and sparsely punctate; antennae longer and stouter than usual, 1 stout, 2 longer than 3, cupuliform; 3 slightly longer than 4, 4–8 close, 9 larger than 8, 10–11 elongate-oval, apical half pubescent. *Prothorax* subconvex, apex lightly arcuate, anterior angles wide and blunt, base very lightly bisinuate, posterior angles subrectangular, sides nearly straight on basal half, arcuately

narrowed on apical, without defined marginal area, disk finely and rather sparsely punctate, without sign of medial line, a smooth foveate depression near base on each side. *Scutellum* large, transverse, oval and punctate. *Elytra* closely applied to and of same width as prothorax, humeri with a blunt, subdentate process; lightly ovate, widest at middle, thence narrowed to apex; subatriate-punctate, the sutural stria only clearly defined, punctures round and distinct, 5th interval lightly convex, the rest flat, with a few minute punctures discernible here and there. *Pro- and meta-sternum* rather strongly, distantly punctate, *abdomen* sparsely and finely so; *femora* very stout, *tibiae* lightly widened at apex, *fore tibiae* curved. *Dim.*—3 mm. long.

*Hab:* Launceston, Tasmania (Lea).

A single example in the Lea Coll. is distinct by the combination of red colour, with appendages and underside concolorous, stout antennae and unusually narrow head, and fine, sparse sculpture. Holotype in the South Australian Museum.

#### CHECK-LIST OF THE AUSTRALIAN COLYDIDAE.

- Bitoma angustula* Motsch ? = *paraliola* Shrp.  
*costata* MacL.  
*cylindrica*, n. sp.  
*occidentalis*, n. sp.  
*puteolata*, n. sp.  
*serricollis* Pasc.  
*siccana* Pasc.  
*Synagathis kauricola*, n. gen. and sp.  
*Larhinotus umbilicatus*, n. sp.  
*Sparactus elongatus* Bkbb.  
*interruptus* Gr.  
*leai*, n. sp.  
*productus* Reitt.  
*proximus* Bkbb.  
*pustulosus* Bkbb.  
*queenslandicus*, n. sp.  
*Phormosa carpentariae* Bkbb.  
*caudata*, n. sp.  
*epitheca* Oll.  
*grouvellei* Bkbb.  
*hilaris* Bkbb.  
*lunaris* Pasc.  
*notata*, n. sp.  
*opacus* Shrp. (*Trionus*)?  
*parva* Bkbb.  
*prolata* Pasc.  
*torrida* Bkbb.  
*Phorminx lyrata*, n. gen. and sp.  
*Bupalia australis*, n. sp.  
*fasciata*, n. sp.  
*variegata*, n. sp.  
*Pabula perforata* Bkbb., n. gen.  
*bovilli* Bkbb.  
*Cebia communis*, n. sp.  
*rufonotata*, n. sp.  
*scabrosa* Reitt.  
*tumulosa*, n. sp.  
*Neotrichus acanthacollis*, n. sp.  
*Colobicus parvulus* Pasc.  
*Ablabus blackburni* Grouv.  
*integricollis*, n. sp.  
*minus*, n. sp.  
*Ablabus nivalis* Bkbb.  
*obscurus* Bkbb.  
*pulcher* Bkbb.  
*tuberculatus*, n. sp.  
*villosus* Lea.  
*Orthocerus australis* Bkbb.  
*Epistranus tibialis*, n. sp.  
*Penthelispa blackburni* Hetsch.  
*fuliginosa* Gr.  
*interstitialis* Bkbb.  
*secula* Pasc.  
*Gompylodes laetrix* Oll.  
*Todina fulvicincta* Elst.  
*fusca* Grouv.  
*lateralis* Bkbb.  
*rufula* Grouv.  
*Meryx aequalis* Bkbb.  
*rugosa* Latr.  
*Dorcetaphrus aequaliceps* Bkbb.  
*alveolatus*, n. sp.  
*analis* Lea.  
*cribriceps* Bkbb.  
*cricksoni* Newm.  
*foesus* Newm.  
*gracilis* Bkbb.  
*ignarus* Pasc.  
*incultus*, n. sp.  
*picena* Germ.  
*popularis* Bkbb.  
*puncticollis* Lea.  
*viduatus* Pasc.  
*xanthorrhoeae* Lea.  
*Ozylaemus leae* Grouv.  
*Metopistes strigicollis*, n. sp.  
*Bothrideres equinus* Pasc.  
*illus* Newm.  
*lobatus* Pasc.  
*mastersi* MacL.  
*puteus* Newm.  
*ustulatus* Lea.  
*vittatus* Newm.  
*Machilotes costatus* Shrp.  
*Leptoglyphus foveifrons* Grouv.  
*Dastarcus confinis* Pasc.

*Dastarcus decorus* Reitt.

*pusillus* Pasc.

*vetustus* Pasc.

*Cerylon alienigenum* Blkb.

*humertidens* Grouv. ?

*longipilis*, n. sp.

*nigrescens*, n. sp.

*Cerylon parviceps*, n. sp.

*Philothermus nitidus* Shrp.

*sanguineus* Broun. ?

*Ocholtsea humeralis* Fairm.

*humeralis* var. *atra* Grouv.

var. *nigricollis* Grouv.

*leai* Grouv.

#### EXPLANATION OF PLATES VIII-IX.

##### Plate viii.

1.—*Bitoma occidentalis*, n. sp.

2.—*Sparactus queenslandicus*, n. sp.

3.—*Bupala australis*, n. sp.

4.—*Bitoma cylindrica*, n. sp.

5.—*Synagathis kauricola*, n. sp.

6.—*Sparactus leai*, n. sp.

7.—*Larinotus umbilicatus*, n. sp.

8.—*Phormesa* (?) *caudata*, n. sp.

9.—*Phorminx lyrata*, n. sp.

10.—*Bupala variegata*, n. sp.

11.—*Phormesa notata*, n. sp.

12.—*Bitoma puteolata*, n. sp.

##### Plate ix.

13.—*Bupala fasciata*, n. sp.

14.—*Cerylon longipilis*, n. sp.

15.—*Neotrichus acanthacollis*, n. sp.

16.—*Cebia tumulosa*, n. sp.

17.—*Ablabus minimus*, n. sp.

18.—*Ablabus tuberculatus*, n. sp.

19.—*Ablabus pulcher* Blkb.

20.—*Pabula dentata* Blkb.

21.—*Ablabus integricollis*, n. sp.

22.—*Epistranus tibialis*, n. sp.

23.—*Cerylon parviceps*, n. sp.

24.—*Metopiestes strigicollis*, n. sp.

THE OCCURRENCE OF THE AUSTRALIAN PILCHARD, *SARDINOPS*  
*NEOPILCHARDUS* (STEIND.),\* AND ITS SPAWNING SEASON IN  
 NEW SOUTH WALES WATERS, TOGETHER WITH BRIEF NOTES  
 ON OTHER NEW SOUTH WALES CLUPEIDS.

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(Plate xi.)

[Read 25th August, 1937.]

It is frequently stated that nothing is known of the shoals of pelagic fish (including the pilchard) in Australian coastal waters. As this statement is certainly incorrect for part of the coast of New South Wales at least, and as the matter of the distribution of this species may be of considerable commercial importance in the near future, the following notes are set out on the discoveries which have recently been made, despite the inefficient means of ocean investigation at our disposal.

During the past five years, whilst accumulating data on the Biology and Hydrography of the coastal waters of New South Wales, the eggs and larvae of the pilchard have been discovered and identified, a piece of work involving a considerable constancy of effort at sea in a small boat. And this has not been confined to one year, or been a matter of accident. The occurrence of these eggs and larvae has been deliberately followed week by week, and at more than one place (at Port Stephens, off Broken Bay, off Port Jackson, and off Port Hacking), and the duration of the spawning season elucidated.

The New South Wales pilchard, *Sardinops neopilchardus* (Steind.) is a medium-sized species of the herring group found at certain seasons in coastal waters in enormous shoals, after the habit of members of this group. Systematists have indicated the resemblance of this species to the true pilchard, *Sardinia pilchardus* of Europe, as well as to *Sardinops coerulea* of the North Pacific Coast of America (now captured in enormous numbers in the great Californian "sardine" industry), to *Sardinops sagrax* (Jenyns) of the coast of Peru, and to *Sardinops melanosticta* (Temminck and Schlegel) of Japan.

The Australian species is not confined to New South Wales waters. It has been recorded as far south as Hobart in Tasmania, and shoals have been recorded as occurring in Tasmanian waters (Johnston, 1882). In Southern Victoria it was noted at an early date, McCoy recording that hundreds of tons were captured in Hobson's Bay as far back as 1864-66 (in August). It has also been taken as

\* *Sardinops neopilchardus* (Steind.) see Whitley (1937); *Sardinia neopilchardus* (Steind.) see McCulloch (1919); *Clupea neopilchardus* Steindachner, *Denkschr. Akad. Wiss. Wien*, xli, 1, 1879, p. 12.

The possibility of making the observations, on which this paper is based, was due in the main to grants for marine research from the Commonwealth Government. I have also to thank Mr. G. Kesteven, Biologist, Fisheries Department, New South Wales, for able assistance at Port Hacking.

far north as Hervey Bay in Queensland. The species is also abundant 1,000 miles eastward, on the New Zealand coast, where it has been systematically fished during the winter.

To return to the Australian coast, we find that steady reports of pilchard shoals have been made since the first records. In 1879 Macleay quoted McCoy's descriptions of how in three successive years (1864-66) in the same month of the year (August) thousands of specimens appeared in Hobson's Bay, southern Victoria, and hundreds of tons were sent to the country markets. "Ships entering the bay passed through closely packed shoals of them for miles." Macleay adds that on the coast of New South Wales it is June and July which are the months of great frequency, but that it is not easy to fix the time within a few weeks. The shoals were described as enormous, covering miles of sea, and accompanied by flights of birds and numbers of large fishes. The shoals were generally observed from one to three miles from the land, and always proceeding in a northerly direction. Probably these records of Macleay are reliable by reason of his knowledge of the subject, but it will be seen later that fishermen frequently make mistakes in their diagnosis of shoals.

Stead, as far back as 1911, in referring to the possibilities of pelagic fisheries, describes the use of a purse seine net, and remarks that records of prodigious shoals on the New South Wales coast have frequently been made. It is also stated that millions have been washed up on the beach at Yamba, Clarence River. Whitley (1937) quotes the date of this occurrence as May, 1911, and this is interesting since a shoal, reputed to be *S. neopilchardus*, came close inshore at Yamba in May, 1937, whilst the author was at that place.

In his previous work (1908) Stead remarks that the shoals are usually of greatest magnitude during *spring* and early *summer* and from his personal experience, in September.

Before touching on the more definite findings which have been made by myself whilst working with the research yacht "*Thistle*", it will be useful to indicate the records of pilchard shoals which have been sent in by the State Fisheries Department's Inspectors stationed along the coast of New South Wales.

Returns are sent in monthly from the fisheries inspectors. From these it would appear that pilchards are seen regularly every month over a long season at some stations. Occasionally notes of great shoals are present.

*Records of occurrence of pilchards off coast of N.S.W. by Inspectors of Fisheries.*

	1934	1935	1936-37
Tweed River . . .	Apr.-Sep.	Apr.-June; Sep., Nov.	---
Richmond River	---	---	Aug., 1936-Jan., 1937
Manning River . .	May-Sep.	Apr.-Aug.	May-Aug., 1936
Wallis Lake . . .	May-Sep.	Mar.-Nov.	All year
Port Stephens . .	Aug.-Sep.	---	Jan.-Feb., 1936; Oct., '36-Apr., '37
Lake Macquarie	---	---	Sep., 1936-Apr., 1937
Terrigal . . . . .	---	Mar.-May, Aug.-Nov.	---
Botany Bay . . . .	May.-Sep.	---	---
Port Hacking . .	May-Sep.	Mar.-June	July-Nov., 1936; Mar.-Apr., 1937
Lake Illawarra . .	---	---	Oct., 1936-Mar., 1937
Clyde River . . . .	---	Oct., Nov.	Sep., 1936-Mar., 1937

The problem of the correct interpretation of these reports is twofold. Of course definite captures of pilchards, from which authoritative diagnosis of specimens has been made, would put certain records out of all doubt. But unfortunately these seem few and are, on the whole, isolated cases, and in any case they supply little or no indication of the length of time the pilchards remained in quantity at the place of observation.

From the point of view of industry, one wants to know for how long and in what sort of quantity the shoals of pilchards remain within any certain limited area of coastal water. A fishery cannot be built up on occasional shoals of pelagic fish whose occurrence might be limited to a week or a few weeks every year, and at varying times.

Some of the Inspectors' reports leave no room for doubt and are extremely valuable in conjunction with our findings. Thus on more than one occasion quantities of pilchard have been driven into the surf by tunny and kingfish and picked up in baskets full. They have also frequently been taken inside snapper when schools were observed.

One Inspector reported that the pilchard worked in towards the coast in April, May and June and described examination indicating that the fish were in roe. He adds that they usually come to the surface at nightfall and are seen by their "phosphorus" (luminescence).

Several reports refer to the tunny, Spanish mackerel, and bonito coming with the pilchard, also to pilchard having been found in salmon and jew-fish.

A more serious criticism applies to the records from fishermen on the coast—the shoals seen from the shore or even from a boat and said to be pilchard may be of some other clupeid species. This criticism receives strong support from the fact that on two occasions within the last six months samples of shoaling clupeids which have been sent in to us by fishermen as pilchards have turned out to be (1) the Maray, and (2) the Sandy Sprat. It is, incidentally, difficult in this connection to see how any safe records could be made from the air unless specimens were being captured at the same time.

One answer to the question asking what amount of absolutely reliable knowledge exists concerning the duration of the occurrence of pilchards in shoals in any one area off our coasts, seems to us to turn on our discoveries of pilchard eggs and larvae. Apart from the published evidence that between May and September shoals of pelagic fish occur, not unlike pilchards in size, and from the capture now and then of fish from these shoals, putting their isolated occurrence as beyond question, there is no real published evidence of continuity. And there was no evidence of the duration of the spawning season before the publication of the paper by Dakin and Colefax (1934).

The first information regarding the spawning places of our pelagic fishes came from the discovery of clupeid eggs in the plankton taken off the coast during the winter months. About the same time, the early stages of clupeid larvae appeared in the catches. Now the recognition of the pilchard eggs in the catches from the coastal waters off Broken Bay, off Port Jackson, off Port Hacking and off Port Stephens, is linked up with the identification of the clupeid larvae (of various stages) which were associated with them.

The capture of clupeid larvae presented more than the usual problem of identification for, whilst the recognition of the larvae as those of a clupeid was not difficult, there are five or six species of Clupeids off this coast, of which the young stages are likely to be extremely similar. None of these early stages had ever been obtained before, and it must be remembered that, since no commercial fishing of these species is taking place even now, no hints for identification could be obtained from the presence of spawning adults. The Clupeids in question are the Pilchard, *Sardinops neopilchardus* (Steind.); the Blue Sprat, *Stolephorus robustus* (Ogilby); the Sandy Sprat, *Hyperlophus vittatus* (Castelnau); the Maray, *Etrumeus jacksoniensis* Macleay; the Herring, *Harengula castelnaui* (Ogilby); and the Freshwater Herring, *Potamalosa novae-hollandiae* (Cuv. and Val.).



It was presumed that, although unlikely, the freshwater herring might produce eggs in the estuaries, which could be carried out to sea. Since the first investigation was made, specimens of this fish with mature reproductive organs have been obtained. They were captured in the Clarence River near Grafton (about 60 miles inland from the sea). The spawning season of this fish is evidently in July and August. It is extremely probable that these eggs are not pelagic at all, but laid on the bottom or attached to other objects. The ovarian eggs in the specimen examined were 1 mm. in diameter.

The method adopted for identification of the larvae was to continue their capture and to collect together a series from which some definite counts of fin rays and vertebrae could be made. This postulated the capture of stages sufficiently developed to indicate certain adult characters useful for this means of diagnosis. Whilst the existing systematic literature gives on occasion the number of fin rays in the fins, the counts often appear to have been made on a single specimen or one or two from the same locality and taken at the same time. Counts of the number of vertebrae are either missing or very unreliable. It was necessary, therefore, to re-examine a number of specimens of the Clupeids concerned in order to obtain more accurate information. The figures given in the table below show the result of this investigation. These figures do not exclude a wider range of variation—examination of a large number of individuals of each species would be required in order to determine such range with absolute certainty. Indeed, there may be different races of the species in Australian waters. With this indication of the need for caution it will be seen that the characters chosen were such as would put the recognition beyond the limits of experimental error.

	Dorsal Fin. Number of Rays.	Anal Fin. Number of Rays.	Number of Vertebrae.	
			Our Counts.	Counts Stated by Other Observers.
Pilchard .. .. .	18	18	50	45 and 49
Blue Sprat .. .. .	12	10-11	47	45
Sandy Sprat .. .. .	15	10	47-48	46
Maray .. .. .	19-21	11	58	
Herring .. .. .	16-18	18-19	41	39
Freshwater Herring ..	15-16	15-18	44-46	46

In the matter of the Herring, *Harengula castelnaui*, the figures for the fin rays given by the original author of the species, Ogilby, are Dorsal 17-19, and Anal 19-21. We have not obtained the highest of these figures in any specimen examined, but it is noteworthy that the number is only 16 for a specimen from the Clarence River and 18 for a specimen from Lake Illawarra. There is remarkable difficulty in obtaining specimens of this fish, although it must be abundant.

The first character to be noted in the small larvae is that the number of vertebrae is 50. Actually the number in front of the anus varies during development—a character noted in other parts of the world for certain Clupeids. It will also be noted (see Dakin and Colefax, 1934) that the dorsal fin gradually moves forward during development.

On the basis of vertebral counts one might, at the outset, eliminate all but the Maray. Actually, however, the vertebral numbers recorded for the Blue Sprat and the Sandy Sprat were regarded as close enough to make other identification characters essential for a reliable diagnosis.

Now, even in larvae of 18 mm., the number of fin rays in the anal fin is sufficient to cut out the Blue Sprat and the Maray. At any larger size the number of fin rays in the dorsal fin cuts out the Sandy Sprat and the Freshwater Herring. The fin rays alone might leave us unable to distinguish between an early stage of the Pilchard and one of the Herring, although, the latter larva not yet having been identified, it is impossible to define its characters. However, the number of fin rays and vertebrae, taken together, leave the result without doubt, for the number of vertebrae in the Herring is the lowest of all the Clupeids concerned.

One reason still to be mentioned for a careful re-examination of the data given above was the discovery of pilchard larvae off the entrance to Broken Bay. These were obtained much earlier in the year than those which were first recognized by us from the coast off Port Jackson, and they presented a slight difference in appearance due to the fact that a conspicuous swelling of the swim bladder was to be noted. It is now assumed that this difference was an effect of the methods of capture: the larvae had previously been taken in surface waters, but the Broken Bay haul was pulled up rather suddenly in a net used for a bottom haul, albeit the depth fished could not be great at this locality owing to the shallowness—10 fathoms.

Comparison of all our larvae set aside as possible pilchard now shows that there is no doubt of the identification. The fact that clupeid eggs formerly identified as pilchard were found in October as well as in the winter months beginning with May led us to a careful measurement of a considerable number of eggs. The range of diameters was exactly the same for the samples concerned.

It is clear, therefore, that the spawning of the pilchard which takes place off the coast of New South Wales occurs over a long season. We can also add that the larvae occur between places as far apart as Port Stephens and Port Hacking, and, since eggs were discovered in large numbers at the latter place, spawning must occur throughout this length of coast at least. A clear indication of the peak of the season, as of the detailed understanding of the length of time the fish may be captured at any one place in quantity, will await the further investigation of an ocean-going research vessel.

Small pilchard larvae varying between 8 and 20 mm. in length have now been taken in the months of April, May, June, July, August, September, October and November. In our first paper on the eggs of the pilchard, we referred to catches made in June, July and August. Since then we have obtained large catches of eggs at the beginning of May (at Port Hacking), and some very large catches in October (off Broken Bay). Since, however, we have obtained larvae in April, it might be assumed that some spawning takes place in February. Possibly eggs may be taken in every month of the year. We have now taken eggs from March to October, with large catches in May, July and October.

In a report of the Marine Station of Portobello, New Zealand, for the year ending March, 1936, it is stated that pilchards are found throughout the year, and it is assumed, from the fact that all sorts of sizes appear, that the breeding season is an extended one. There is, however, no mention of scientific evidence. Another reference gives November and December as the spawning season.

It is interesting to make some comparison with the Californian pilchard whose habits are now comparatively well known. According to Dr. Frances

Clark, the maximum area of spawning of the Californian pilchard occupies a region 200 miles north and south and 100 miles in width, although a general spawning takes place over 1,600 miles of coast (measured north and south). The spawning season extends from February to August with peaks in April and May. But as this is the Northern Hemisphere, the months correspond, in Australia, to the period from August *through the summer to February*, with a peak in October and November. It is difficult for us to make accurate comparisons because, though we have taken a great haul of eggs as late as October, our work at sea has been least intense in summer owing to various difficulties associated with our oceanographical work.

It would appear, however, that the spawning season of the Australian pilchard off the coast of New South Wales definitely extends over quite as long a period as that of the Californian pilchard. It has been noted above that spawning pilchards have been recorded at Portobello, New Zealand, in November and December. The latitude of this place is considerably south of Sydney. Another New Zealand reference (Report on Fisheries, N.Z., 1933) states that pilchard eggs were taken during December and January by tow-netting. It is interesting to note that whilst the European pilchard has been observed to spawn off the English Channel in the summer months of July and August, the same species spawns in the Mediterranean during the winter. In this case, however, the spawning season lasts practically the whole year, with a maximum from December to February—i.e., a maximum in the three *winter* months.

Strictly speaking, the term "Sardine" should be confined to the young of the pilchard. In California it is used for the adult pilchard as well. Now one of the most interesting discoveries bearing on the occurrence of pilchard eggs and larvae in New South Wales waters was the catching of a shoal of small sardines inside the estuary of the Hawkesbury—well up in the Pittwater to be exact, on 3rd October, 1936. The specimens (see Plate XI, fig. 1) were obtained with a hand net by my Research Assistant, Miss I. Bennett. At 4 o'clock in the afternoon (low water 3.57 p.m.) a small shoal of these young fish, which must have contained millions, appeared along the beach. The visible area extended about 400 feet in the direction along the beach and 50 feet outwards. This was merely the area where they were breaking water. The water ranged from a foot in depth to about ten feet. The fish were crowded together so that a scoop with a bucket was like scooping out the contents of a fishing net. The length of the specimens obtained varied from 38 mm. to 56 mm. Since these individuals might be regarded as two-three months old, the observations indicate that considerable numbers of eggs were spawned off our coast in June-July, 1936, fitting in excellently with our captures of eggs and larvae in 1932, 1933 and 1934. This discovery also indicates how some of the early stages may enter into inshore estuarine waters. It is still unknown to what extent this migration is typical of the life-history of our fish and, although we have been specializing for several years on the planktonic and post-larval stages, it is significant that we have never observed such a shoal of small sardines in these inshore waters before. The difficulty of the non-systematist distinguishing between the small fish species which are abundant in the same localities renders observations by fishermen once again of very little count. The discovery was, in any case, a very valuable one in providing further support for the diagnosis of the pilchard larvae.

It is noteworthy that in 1935 we sailed through shoals of pilchard at the entrance to Broken Bay in the month of May (four consecutive weeks). The fish were packed in shoals over an area of two or three square miles, often breaking

water and making the sea surface look as if struck by gusts of wind. Large numbers of gulls and terns were diving after the fish.

In 1937 nothing of this kind appeared at Broken Bay during the same period, although odd eggs and pilchard larvae were being taken. But large numbers of the eggs were captured at Port Hacking during these weeks, and the activity of the gulls was noted off Port Jackson at the same time.

On the 18th of July (that is, about two months later) shoals of fish appeared at Broken Bay, and with them the gulls and terns performing the same feats of diving. Plankton catches were made and the results were striking; we had one of the largest hauls of pilchard eggs we had ever taken. The sequence of dates seems worthy of record.

It is worth recording here that shoals of Maray were seen and fish captured near the entrance of Sydney Harbour (off the Quarantine Station) in the month of August. These fish had undeveloped reproductive organs. They averaged 16 centimetres, say  $6\frac{1}{2}$  inches, in length. It is rather surprising to find in McCulloch's "Fishes of New South Wales" (1934) a statement to the effect that the Maray is a southern fish, not common in New South Wales waters. It would appear that this is decidedly not the case.

Shoals of Sandy Sprat,  $3\frac{1}{2}$  inches in length, were about the entrance to Port Jackson in June (1937). Specimens of these were captured by fishermen and sent in to market where they were sold as Sardines! The reproductive organs were on their way to maturity.

Finally, catches of Freshwater Herring were sent from Grafton on the Clarence River to the Sydney markets in July (1937) and sold as Herring, without any qualifying adjectives. These were absolutely mature, the gonads being completely ripe. There is little or no evidence to indicate that these fish deposit their eggs in ocean water, even in the estuary mouths, and it would appear very likely that the eggs of this Clupeid are demersal.

The locality of capture was actually twenty-three miles up-river from Grafton. Analyses of the river water at Grafton at the time showed that the salinity was only 0.54‰ at low water and 1.57‰ at high water as compared with 35‰ for ocean water.

Confirmation of the above in regard to the Freshwater Herring is also to be obtained from the fact that McCulloch (1917) noted that specimens taken from fresh water in the Hastings River in March, 1916, had developed milt and roe. The length of these fish was 8 inches; ours from Grafton ranged from 10 to 12 inches in length (Plate xi, figs. 3, 4).

#### SUMMARY.

1. Further observations are set out concerning the diagnosis and identification of the larvae of the Australian Pilchard taken in New South Wales coastal waters.

2. Evidence is produced to show that the breeding season of the Pilchard extends through a very long period and that probably eggs are obtainable in every month of the year.

3. A shoal of young sardines, length 38-56 mm. and probably only 2-3 months old, was investigated, occurring in October inside the estuary of the Hawkesbury River.

4. Shoals of Sandy Sprat occur close in to the coast and enter the estuaries in June. The gonads in that month are approaching maturity.

5. Shoals of Maray have entered Sydney Harbour in August-September. The fish had undeveloped reproductive organs---probably spent.

6. The Freshwater Herring in the fully mature state has been taken at Grafton, Clarence River, in fresh water. The eggs are very likely demersal.

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DESCRIPTION OF PLATE XI.

Fig. 1.—Part of catch of Sardines (young of pilchard, *Sardinops neopilchardus* (Steind.)), from Pittwater, New South Wales.

Fig. 2.—Pilchard larva 17 mm. in length (stained by Van Wijhe method).

Figs. 3, 4.—Mature Freshwater Herring (*Potamalosa novae-hollandiae*) from the Clarence River, Grafton, N.S.W. 3, Male; 4, Female.

NOTES ON THE BIOLOGY OF *TABANUS FROGGATTI*, *T. GENTILIS*, AND  
*T. NEOBASALIS* (DIPTERA).

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(Plate x; thirteen Text-figures.)

[Read 26th August, 1937.]

*TABANUS FROGGATTI* Ric.  
*Systematics and Distribution.*

*Tabanus froggatti* is a small, dark, hairy-eyed species, which was described by Ricardo (1915) from a female from Mr. Froggatt's collection. My specimens agree closely with one from Mr. Froggatt's series, and also with Miss Ricardo's description. But, in addition to the markings described by Ricardo, all specimens of *T. froggatti* which I have seen possess a large, triangular, tomentose, grey spot each side of the median spot on the second abdominal segment. This occurs in both sexes, but is obscured in greasy or rubbed specimens. The male, of which I have not been able to find a published description, differs from the female chiefly in having the upper facets of the eyes enlarged, the eyes densely clothed with black hairs, with some gold intermingled on the lower half, and in the possession of very long black hairs on the first two antennal segments. The whitish pubescence of the female is replaced by gold in the male, and the small median spots on the abdominal segments are clothed with gold hairs. The eyes of the female are bronzy green, and of the male bright emerald-green when alive. In general the male has a darker appearance than the female, owing to the profusion of black hair on the thorax and abdomen, and is larger, although there is considerable variation in the size of both sexes. The largest male was 14 mm. long, and the smallest female 8 mm.

The type and another specimen from Mr. Froggatt's collection are from the south coast of New South Wales. The only other distribution record known to me is Canberra.

*Notes on Life-History and Habits.*

The adults of *Tabanus froggatti* are on the wing in Canberra during October and November. They are very numerous in the vicinity of Black Mt. (2,668 ft.) during these months. Both sexes may be taken feeding on small flowers among the pasture, and also on low-growing *Leptospermum* on the hill slopes. The females attack cattle and humans, but are not as quick and strong in flight as many other biting species. They hover over and alight on swampy ground, crawling over mud and grass, and do not appear to drink while flying but when standing on the edge of small pools. During the second week in October, 1936, the flies were extremely numerous, swarming on the grass and worrying cattle. They were only active on bright, calm days.

Females bred in captivity refused to bite, and only a small proportion of the captured flies kept in cages bit readily. One female fed to repletion on my arm on 20th Oct., took a smaller feed on 21st and 22nd, but would not feed again (Plate x, fig. 2). A number of captured flies of both sexes were put into a field cage with food and water, and a rat was provided for blood feeds. Under these conditions the flies lived no longer than 8 or 9 days, and no egg masses were produced. Cameron notes that in British and North American Tabanids only fertilized females will bite, and in the case of *Haematopota pluvialis* it is exceptional for the female to bite more than once before oviposition, which takes 6 to 12 days after the feed.

The larvae of *T. froggatti* were found in the soil on the slopes of Black Mt. (Plate x, fig. 1). They were most abundant in the banks of a permanent swamp caused by the outflow from a septic tank, but were also found adjacent to small transient swamps produced by the drainage from taps. They live below the soil from just under the grass to a depth of two inches, and somewhat deeper on the banks of drains. When about to pupate they may be right on the surface among grass and debris. The larvae were found at various stages of development, indicating that they are never aquatic, but live in more or less moist soil all their lives. The larvae of *T. froggatti* were much more abundant than *T. neobasalis*, which occurred with them, and have not been found elsewhere than Black Mt. They were always obtained by digging and turning the soil, and breaking the clods. None were found by sieving wet mud, or by netting in the water among weeds and algae.

The larvae were present in the soil from 15th August to 10th October, 1935, and during September, 1936. As many as 20 may be dug out in half an hour near the permanent swamp. For the last week of collecting, practically all the larvae found were prepupal, and later digging yielded only pupae, which could be found until November. During May and June, 1936, a few large larvae were dug from the soil beneath sheep carcasses which had been lying since March on a higher, dry slope of the mountain. This part receives no drainage, and in summer is very dry, although the soil under the carcasses where the larvae were found was naturally somewhat moist.

The soil in which the larvae occurred harboured also numerous earthworms, a few Calliphorid larvae, and some larvae of the Tipulid, *Ischnotoma* species. *T. froggatti* attacked earthworms and soon destroyed those supplied as food. When kept in one container they readily bite and feed on each other, and when handled struggle vigorously, thrusting out the mandible and maxilla on one, or occasionally both, sides with a distinct clicking sound.

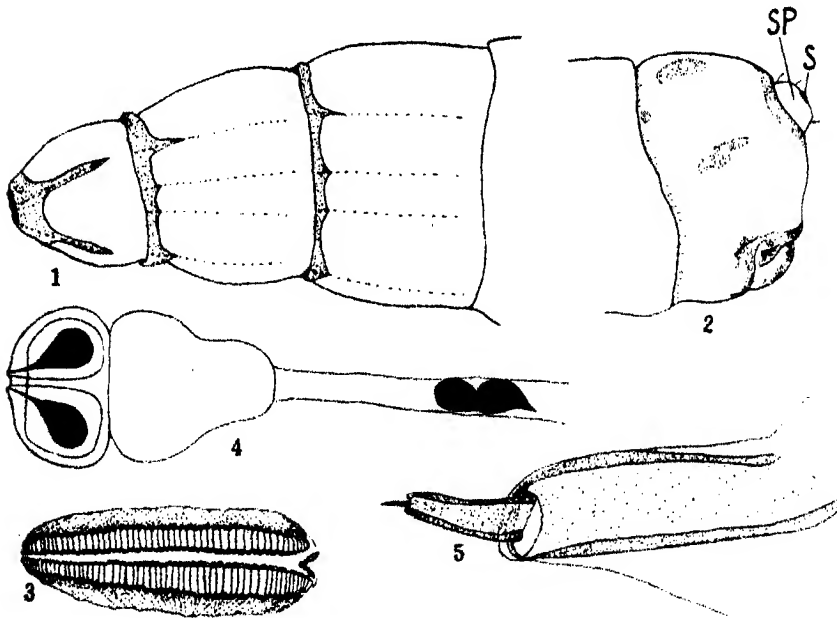
The length of the larval life is not known, but the evidence available indicates that the life cycle occupies one year. The larvae seem to reach full growth in summer and autumn, remain in a dormant state through winter, then feed again in spring before pupating.

#### *The Larva* (Plate x, figs. 5, 6).

The smallest larva was 11 mm. and the largest 22 mm. in length, with every gradation between. They were measured after being killed, being slightly longer when alive and fully extended. The following description is taken from a live larva: The skin is shining, and strongly, evenly and coarsely striated. It is sufficiently transparent for the internal organs to be visible. There is no pigment in the skin, which is uniformly cream to pale yellowish, often with a greenish tinge. The spiracle is orange, and the mouth parts brownish in colour. The

complete head is visible through the skin of the thorax, and Graber's organ is readily distinguishable beneath the dorsal surface of the eighth abdominal segment. Certain rugose portions of the skin appear to be pale brown on freshly collected larvae, but this is due to the particles of soil adhering to them. The dorsal vessel contains a bright green granular material, which gives the appearance of a green median stripe. The stomach contents are the reddish colour of earthworms.

The larva is narrow and elongated, tapering both ends, but more noticeably at the anterior end. The thoracic segments have a band of finely rugose skin round the anterior border, that on the first segment being widest (Text-fig. 1). In each segment the dorsum is marked off by a pair of narrow projections of rugose skin running back from the anterior band, and the lateral areas are marked off from the ventral in a similar manner. The first segment has a central projection on the ventral area, whilst the second and third have a pair of ventral projections. The abdominal segments have not a complete anterior ring of rugose skin as have the thoracic segments, but there is a slightly raised transverse ridge, both dorsally and ventrally, just behind the anterior margin in the first seven abdominal segments. This ridge is covered with rugose skin, and on the ventral surface bears a pair of blunt prominences. In some larvae each of these is divided into two by a slight depression. Laterally there is a strong, blunt, rugose papilla, the pair on the first and seventh abdominal segments being less prominent than the others. The abdominal segments are divided into dorsal, lateral and ventral areas by fine lines of dots situated in slight furrows. These are spots where muscles are attached to the skin. The eighth abdominal segment is short and broad,



Text-figs. 1-5.—*Tabanus froggatti*.

1. Anterior end of larva (stained),  $\times 20$ .—2. Posterior end,  $\times 20$ .—3. Posterior spiracle,  $\times 200$ .—4. Graber's organ,  $\times 300$ .—5. Antenna,  $\times 140$ .



being a little less than half as long as the others (Text-fig. 2). The skin is more coarsely striated than the rest of the body. The large anus, situated ventrally, has prominent swollen lips, and is surrounded by a fleshy ridge of rugose skin. The segment slopes backwards from the anus to the small postero-dorsal prominence which bears the spiracle, and which represents the siphon of aquatic Tabanid larvae. The spiracular prominence is surrounded by a circle of rugose skin. A pair of small pilose patches occurs dorsally, with another pair laterally. In some larvae there is another very small patch anterior to and between the dorsal and lateral patches. The rest of the segment is evenly striated.

On the ventral surface of each thoracic segment and about the centre, a pair of small hairs arise, one each side of the mid-line. There are also a few minute hairs on the dorsal and lateral areas of the thoracic segments. The abdominal segments, with the exception of the last, bear a transverse series of six hairs ventrally, in the anterior half, and there is a similar series of weaker hairs dorsally, and four on the lateral areas.

*The spiracles.* (Text-fig. 3.)

The tracheal trunks converge towards the spiracular prominence in the eighth abdominal segment. When they enter the prominence each ends in a large, laterally compressed felt-chamber, these being closely coherent. Through a vertical slit in the skin of the prominence the stigmata emerge as a pair of curved ridges crossed by a series of chitinous bars, giving them a "scalloped" appearance. The edges of the slit are marked by a row of tiny finger-like protuberances. These, with the stigmata and the felt-chambers, are coloured orange. The slit may be closed against the stigmata or expanded outwards, allowing an air passage down each side, called the "Vorraum des Stigmas" by Stammer (1924). The spiracular prominence bears small setae in groups of three. A pair of these occur at the upper and lower corners, and a smaller one just below the middle, each side of the spiracle.

The anterior spiracles are only visible with the naked eye when the larva is about to pupate, and the head is permanently withdrawn. They are a pair of slender lateral tubes projecting straight out from the first thoracic segment near its posterior margin. The surface shows a curved stigma with a scalloped appearance as in the posterior spiracle. The felt-chamber runs the length of the external tube.

The skin of the larva is of three layers: the outer thick striated skin, a median smooth glassy layer and a thin elastic inner layer. Special muscles attached to the skin cause a pattern of small dots on the surface in the slight furrows separating the various regions of the segments. The other muscles are attached beneath the rugose parts of the skin. The rugose skin is formed by the pinching up of the surface into wavy ridges, each ridge being finely papillate, with some approaching more to setose, the small projections varying from blunt to sharp pointed. All are directed backwards. The form of this skin is the same in every part where it occurs, but in places it is more finely ridged and papillate than in others.

*Graher's organ.* (Text-fig. 4.)

This is visible under the skin of the dorsal surface of the eighth abdominal segment, just anterior to the spiracular prominence, and opens to the surface through a tiny funnel-shaped depression at the junction of the eighth segment and the prominence. The surface of the body is curved here and the opening

is only visible from the posterior view. The organ consists of a small terminal chamber divided into two by a longitudinal vertical wall, each division containing a round black body attached to the top end by a stalk. Behind the terminal section is an empty pear-shaped chamber from which a long narrow tube runs to the opening, and contains two detached black bodies near the posterior end. All the black bodies are the same size. In all the Tabanid larvae examined Graber's organ was the same, probably the normal condition for the last instar.

*The head.*

The head when withdrawn reaches the posterior edge of the second thoracic segment, and when the segments are also contracted and telescoped it reaches the first abdominal segment. When fully extended it just projects into the second thoracic segment. There is an extension of the finely rugose skin of the fore-border of the first thoracic segment, which forms a thin membrane over the head to the base of the mouth parts. When the head is withdrawn, this membrane forms a long invaginated tube with the mouth parts at the bottom.

The epicranium consists of smooth chitin, heavily pigmented in the posterior two-thirds, especially towards the sides, and with the dark brown marking produced back into two fine points posteriorly where the plate fuses with the ends of the tentorial rods. Anteriorly the epicranium curves round the sides to form the lateralia, and medianly it is produced into the rostrum. There is a black eye-spot on either side beneath the surface of the lateralia and on a level with the gular plate.

The hollow tentorial rods run the length of the head from the base of the mouth parts. They converge and take an upward curve near the anterior end just above the eye spots, and in this region are connected with the epicranium by a curved chitinous bar. Just behind the mouth parts the rods fork, the outer and shorter branch, which is strongly chitinized at the end, articulating with the base of the maxilla, and the inner and longer projects into the back of the closed buccal cavity. At the posterior end they expand into a thin wing-like portion which joins the end of the epicranium.

The chitinous pharynx runs from the labium beneath the tentorial rods in the centre of the head ventrally, for half the length of the head and then between the rods to the end, where it expands slightly. The floor is most heavily chitinized, appearing as a bar from the side. In cross-section the pharynx is V-shaped. The salivary pump is situated ventrally near the middle of the head. It is large, oval with a concave, strongly chitinized, upper surface and a thinner convex lower surface. A wide duct connects with the labium at the anterior end, and from the posterior end a duct leads to the glands. There are valve structures where these ducts join the pump.

The antenna (Text-fig. 5) arises from the end of an elongated plate of the lateralia. This plate projects from the surface and has well-defined limits, giving it the appearance of a basal segment of the antenna. The first antennal segment is elongate and cylindrical, with the apical segment very fine, pointed and bifid. The clump of spines which appears as a brown spot behind the base of the antenna is close to the inner side of the antenna.

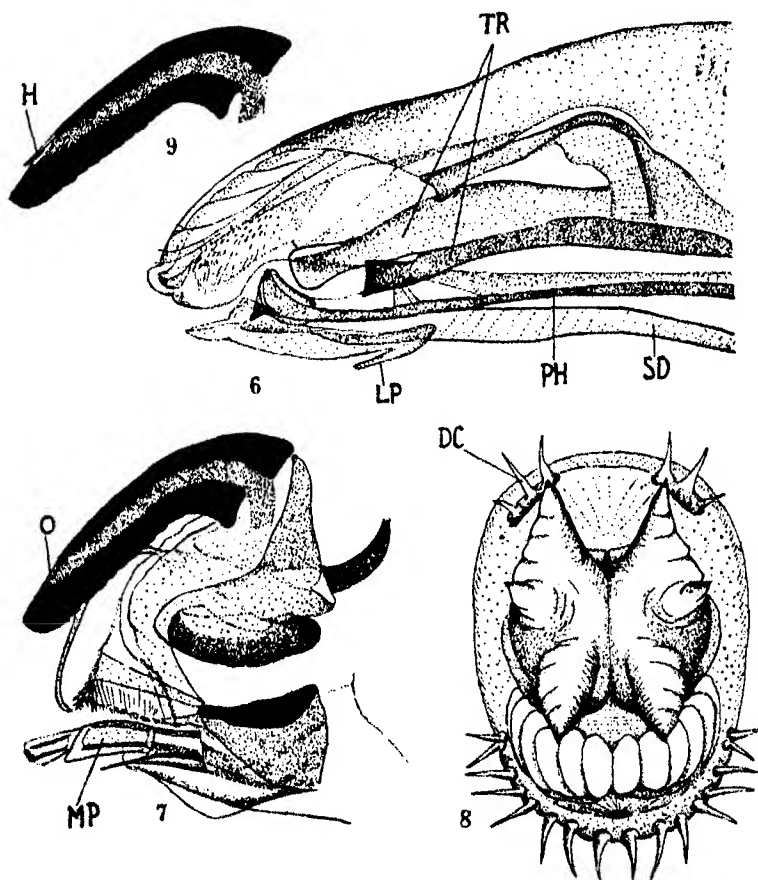
*Mouth parts.*

With the exception of the mandibles the mouth parts are of transparent, nearly colourless chitin. The most anterior point of the head is the up-turned tip of the labrum, which projects out between the mandibles. The labium, in touch with the lower surface of the labrum, does not extend so far forward. The mandibles lie close to the median labrum and labium, and outside and a little

below these are the maxillae, their palps extending in front of, below and slightly inside the antennae. Dorsally, between the base of the mandibles and the antennae, are the two bunches of "piercing spines".

The labrum (Text-fig. 6) is laterally compressed, with the upper edge most strongly chitinized and consisting of a down-curved narrow trough continuing from the rostrum. The anterior extremity is a small up-turned tip. On the ventral surface there is a small invagination where an upgrowth from the labium-pharynx projects. Just in front of this there is a region covered with hairs and small furrows. On the edges of the upper curved surface there are four pairs of sensory hairs arising from tiny pits.

The labium (Text-fig. 6) is a delicate dorso-ventrally flattened plate ending anteriorly in two pointed glossae, and bearing on the ventral surface near the



Text-figs. 6-9.—*Tabanus froggatti* and *T. gentilis*.  
6. Labrum and labium,  $\times 100$ ; *lp*, labial palp; *ph*, pharynx; *sd*, salivary duct; *tr*, tentorial rod.—7. Mandible and maxilla,  $\times 140$ ; *o*, mandibular orifice; *mp*, maxillary palp.—8. Posterior end of male pupa,  $\times 60$ ; *dc*, dorso-lateral comb.—9. Mandible of *T. gentilis*,  $\times 140$ ; *h*, hair above orifice.

posterior extremity a pair of slender forwardly-projecting palps. The palp is one-segmented with a group of sensillae at the apex. The labium bears a few fine hairs on an upgrowth of the dorsal surface near the glossae. A large duct from the salivary pump runs into the labium and opens between the glossae on the dorsal surface. The upper surface of the labium is fused with the anterior end of the pharynx, there being a peg-like projection just behind the glossae attached to the lower surface of the labrum.

The mandible (Text-fig. 7) is composed of heavy black chitin, is slightly curved and has a blunt apex, behind which the longitudinal canal opens on the dorsal surface. It is strongly toothed along the lower concave surface. The maxilla (Text-fig. 7) is triangular in shape, of thin chitin, with the short rounded tip extending a little in front of the mandible. The anterior edge below the tip is fringed and haired. A large palp arises from the lower anterior edge. It has a short wide basal segment with an upgrowth bearing a hair on the outer side, a median elongated segment, and a short blunt apical segment. There are two thick chitinous sclerites at the base of the maxilla connected with the tentorium. A short curved bar, running from the outer surface at the back of the maxilla, also connects them with the bunch of spines, which are stiff, light brown, and simple or bifid.

*The Pupa.* (Plate x, fig. 3.)

The pupa is slightly curved throughout its length, the dorsal surface being convex. It is 14 to 16 mm. in length. When newly formed the colour is bright bluish-green, which changes with development to dull whitish-green on the abdomen and dark brown on the thorax and head. A few days prior to emergence the whole pupa becomes black. It is slender, the greatest width being approximately 4 mm. The shell left after emergence of the fly is of delicate, semi-transparent chitin.

The chitin of the head and thorax is wrinkled all over. On top of the head is a pair of prominences, each bearing a double bristle. On the back of the head there is another pair. Below the antennae on the ventral surface are two pairs of bristles, the upper pair being the further from the centre. Near the base of the leg-sheaths each side is a prominence bearing a double bristle, and laterally there is a bristle at the base of each wing-sheath.

The prominent ear-shaped mounds of the thoracic spiracles are dorso-lateral and just behind the eyes. The slit is in the form of a wide C. On the dorsum of the thorax are two pairs of large bristles. The narrow metathorax bears three pairs of bristles laterally. The tips of the wing-sheaths reach to the second abdominal segment. Each of the abdominal segments except the last is divided into dorsal, lateral and ventral areas by longitudinal furrows. The lateral region appears as a narrow ridge running the length of the abdomen. Near the centre of each segment on this lateral ridge is a spiracle in the form of a small backward-pointing projection, with a curved scroll-shaped slit, the opening of the scroll being anterior. Each segment except the last bears a girdle of spines on the posterior half. The first segment has only two pairs of spines dorsally and three laterally, in place of the complete circle of spines. Between the setose girdle and the posterior border of the segment the chitin is finely rugose, and there is a similar rugose band at the anterior border. The rest of the segment is much more coarsely wrinkled. The spines are long, stiff and straw-coloured, somewhat variable in length, with a series of very short spines in front of them.

The last abdominal segment bears the typical aster (Text-fig. 8) of six large pointed projections. The two lower and side arms are approximately the same size, with the upper pair slightly smaller. In the male the dorso-lateral combs have three bristles, two large and one small. These vary to some extent. There is a large anal tubercle with a continuous row of spines beneath. In the female pupa the arms of the aster are smaller and not so spreading, the bristles of the dorso-lateral combs are equal in size, the anal tubercle is small, and there is a median gap in the row of bristles beneath.

*TABANUS GENTILIS* Erich.

*Systematics and Distribution.*

*Tabanus gentilis* is very similar to *T. froggatti*, and doubtless often confused with it. The differences in the two species have been pointed out by Ricardo (1915). It appears to have a wider distribution than *T. froggatti*, being recorded from Barrington Tops, Klandra, Kosciusko and Countegany, N.S.W.; Mts. Tidbinbilla and Tinderry, F.C.T.; and Tasmania. Taylor (1918) also records it from King George Sound, W.A.

*Notes on Life-History and Habits.*

*T. gentilis* has only been observed on the wing at Countegany (4,000 ft. approx.). It was abundant at the end of January, flying low over grass and swamps in a similar manner to *T. froggatti*, although it gave the impression of being a lighter-coloured fly. It was active only in bright sunlight, and attacked cattle and humans, being rather more persistent and stronger in flight than *T. froggatti*. This species was also collected feeding on *Leptospermum* and *Epacris* flowers in the swamps.

The larvae were only collected once, during October, 1936, near the summit of Mt. Tinderry (5,307 ft.). They occurred in dry soil, above and to the side of a swamp. The soil contained no earthworms, but numerous Bibionid larvae were present. They were very close to the surface under short grass, in the driest parts. Their remarkable abundance may be judged by the fact that an area approximately 15 by 4 feet yielded 36 larvae in an hour's digging.

*The Larva.*

The larva is very similar to that of *T. froggatti*, being distinguishable chiefly by the chalk-white colour, all the *T. froggatti* larvae seen being cream or yellowish. It differs also in being slightly more robust, in having more opaque skin, which is rather more coarsely striated, and in the rugose girdles and patches being more distinct and obvious. The details of the rugose marks and patches are the same as in *T. froggatti*. A close examination of the head and mouth parts revealed no essential differences from *T. froggatti*, with the exception of a small structure on the mandible (Text-fig. 9). This was noticed in *T. gentilis* only, and consists of a delicate setose-like projection arising from the posterior margin of the aperture on the dorsum of the mandible. It projects forwards across the pore, and has a series of fine hairs on the underside. It is frequently depressed, lying flush with the surface or pressed into the aperture. Although this structure has not been described in any other Tabanid mandible it is possibly present, being extremely difficult to detect when depressed into the pore. It could not be discerned with certainty in *T. froggatti* or *T. neobasalis*.

*The Pupa.*

This is essentially the same as in *T. froggatti*. The spines encircling the segments are slightly longer. The aster is the same in shape and structure, but

the dorso-lateral combs are larger, with the three spines approximately the same length, and longer than in *T. froggatti*. The distinguishing feature, however, is the presence of lateral combs, which are entirely lacking in *T. froggatti*. They are small rounded swellings, with ten to twelve short bristles.

*TABANUS NEOBASALIS* Tayl.

*Systematics and Distribution.*

*T. neobasalis*, which was redescribed from the type female and another specimen from Tamworth by Ricardo (1915), was originally given the name *basalis* by Walker. Taylor (1918) pointed out that Macquart had previously used *basalis*, and changed the name to *neobasalis*. Ferguson and Henry (1920) note that *T. neobasalis* is not always easy to distinguish from *T. circumdatus* in the field, but is usually rare.

My bred specimens agree with Ricardo's description. The male, which has not been described, differs from the female in having densely pubescent eyes, with the facets of the upper two-thirds enlarged. The hairs on the lower third are shorter and blacker, whilst those on the upper part are longer and browner. The whole body is more densely haired, especially on the thorax which, in addition to the appressed gold hairs of the female, has a thick covering of long yellow and black hairs. The median pale marks overlying the black stripe of the dorsum of the abdomen are not usually so noticeable in the male as in the female. The eyes of both sexes are always dull brown. The length varied from 11 to 14 mm.

The species has been recorded from Canberra, Brindabella, Tidbinbilla, Wee Jasper, Yarrangobilly, Alpine Creek, Tamworth, Wolseley and Kendall.

*Notes on Life-History and Habits.*

*Tabanus neobasalis* is not so abundant in Canberra as *T. froggatti*, only occasional individuals having been observed and collected in the field. They occur in December and January. Females attack cattle, and are more elusive and swift in flight than *T. froggatti*. One fly was observed attempting to bite a sheep carcass.

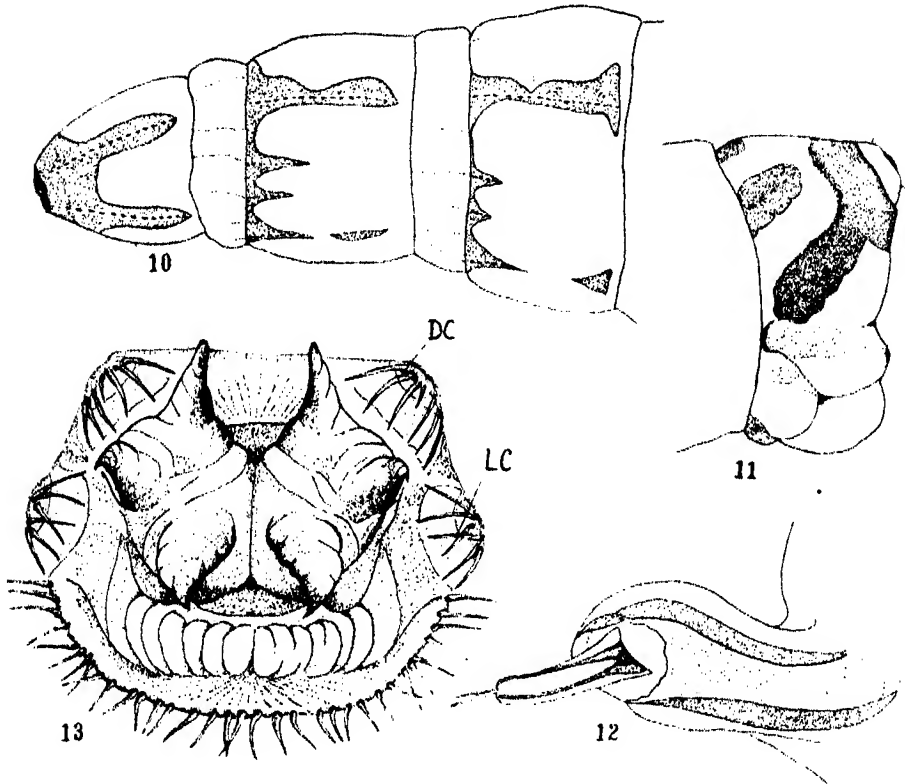
The larvae were found in company with those of *T. froggatti* from 14th August to 18th November, 1935, being present after *T. froggatti* had all pupated. They were more numerous in September, 1936, as many as six being dug up in half an hour. They were also found on the edges of swamps at Mt. Tidbinbilla (5,124 ft.), Mt. Coree (4,663 ft.), and Mt. Tinderry (5,307 ft.). Like *T. froggatti*, they were found only in soil and never in mud. The feeding habits were not observed, but the larvae were always associated with earthworms.

Of several pupae collected in the field one produced a small parasite, which was later identified as a species of *Spilomicrus*.

*The Larva.* (Plate x, figs. 7, 8.)

The larva is thicker and more robust in appearance than that of *T. froggatti*. The length of those examined varied from 14 to 23 mm., and the greatest width was 5 mm. The colour is deep cream to pale yellow, the skin is transparent and strongly and evenly striated all over except in certain hirsute areas. The striations are coarser than in *T. froggatti*, but the dark brown marks on the dorsal surface readily distinguish it from *T. froggatti*. There is no pigmentation as in *Scaptia* larvae, the colour of the marks being due entirely to the close massing of fine hairs, which vary from straw colour to a deep brown according to their position. The thoracic segments (Text-fig. 10) each have a wide, light brown hirsute band at the fore border, that on the first segment being much narrower than in

*T. froggatti*. In all the abdominal segments there is a posterior band of hairs as well. The marks on the thorax correspond to the pale lines in *T. froggatti*, which in that species are only clearly visible when stained. In *T. neobasalis* they are dark brown, the dorso-lateral pair being especially well developed.



Text-figs. 10-13.—*Tabanus neobasalis*.

10. Anterior end of larva,  $\times 20$ .—11. Posterior end,  $\times 20$ .—12. Antenna,  $\times 140$ .—13. Posterior end of male pupa,  $\times 60$ ; dc, dorso-lateral comb; lc, lateral comb.

On the abdominal segments there is a mid-dorsal dark brown spot on the anterior hirsute band, extending the width of the band and projecting on to the striated surface posteriorly, and the hind border of the previous segment anteriorly. Corresponding to the dorso-lateral lines in *T. froggatti* there are dark brown triangular marks projecting back from the hirsute band and forwards from the posterior border of each segment, their points approaching and in some old larvae and prepupae joining to form a longitudinal stripe. In most larvae they form a stripe on the seventh segment. The eighth abdominal segment (Text-fig. 11) has a pair of large dorsal patches corresponding in position to the dorso-lateral marks on the other segments, and a smaller central patch near the fore-border. In old larvae the dorsal patches extend to join the wide dark ring of hirsute skin surrounding the spiracular prominence. In all larvae a lateral

band connects this ring to the skin around the anus, which is hirsute, but lighter in colour than the dorsal patches. The anus and surrounding ridge is much larger and more prominent than in *T. froggatti*.

The spiracular prominence is striated, the striae curving and twisting in many directions. The hairs have the same arrangement as in *T. froggatti*, and are also in groups of three. The spiracles and felt-chambers are dark brown.

The rows of dots representing muscle attachments on the skin occur in the same position as in *T. froggatti*, and are associated with the dark brown marks. The actual spots are much larger. The rows of delicate hairs on the thorax and abdomen are similar to those in *T. froggatti*. Graber's organ is the same as in *T. froggatti*, and is visible from the dorsal surface, except in old larvae with extensive marks, lying between the posterior ends of the dorsal marks and in front of the ring round the spiracular prominence.

#### *The head.*

In general, the features of the head, tentorium and mouth parts are the same as in *T. froggatti*. There are, however, some slight differences in detail. The head and mouth parts are rather more strongly chitinized and are larger and stronger. The eye-spots are darker and more conspicuous. The salivary pump is larger and more elongated. The mandibles are longer, narrower and darker. The "piercing spines" form a larger and more noticeable spot, and they are individually longer and denser. Whereas these spines are simple or bifid in *T. froggatti*, in *T. neobasalis* they are bifid, trifid, and a few have four points, the main fork being long and the others smaller and spread out fan-wise. The wing-like posterior end of the tentorial rod has a thin strip of the chitin on its dorsal surface darkened, making a distinct mark. The labium has a more pronounced dorsal projection associated with the end of the pharynx, and the glossae are narrower and more pointed. The up-turned tip of the labrum is slightly different in shape, the dorsal trough is deeper, and the hairs longer. The under surface is much more hairy, there being a long fringe projecting from each side of the small pad in front of the junction with the pharynx, and a row of hairs along the sides where it roofs the buccal cavity. The antenna (Text-fig. 12) is similar to *T. froggatti*, but the first segment is slightly longer and narrower, and the bifid apex longer and stronger.

#### *The Pupa.* (Plate x, fig. 4.)

The pupa has the same shape as in *T. froggatti*, and is 15 to 17 mm. long and 5 mm. at its greatest width. It is darker in colour, has greenish tinges on the abdomen and dark brown to black shadings on the head and thorax. The chitin is thicker and firmer, and is shining and glossy, that on the thorax being smoother than in *T. froggatti*. The spines on the head and thorax are the same, but the anterior ring of smaller spines in front of the girdle of larger ones on the abdominal segments is better developed and more conspicuous, and the larger spines are longer and denser.

The chief differences are in the shape and size of the thoracic spiracles, which are larger and flatter than in *T. froggatti*, and of smoother, shining chitin, and in the details of the aster (Text-fig. 13). The slits of the abdominal spiracles are in the form of a wide C, rather than scroll-shaped as in *T. froggatti*. The dorso-lateral combs bear six bristles, and lateral combs also bearing six bristles are present in addition.



## DISCUSSION.

The *Tabanus* larvae described above differ in three major characteristics from European and American species.

1. All other species described have the thoracic segments unstriated on the dorsum. Stammer (1924) uses this character in a key to genera. Under *Tabanus* he says, "the dorsal face of the thorax less striated than the rest of the body or completely free from longitudinal striations". Under *Hexatoma* he says, "thorax striated like the rest of the body", which latter description agrees with my larvae. Marchand (1920) states that the thorax is striated above in *Chrysops* and smooth or nearly so in *Tabanus*. In his general description of Tabanid larvae, Stone (1930) says that the striae of the skin are lacking in the dorsum of the thorax in *Tabanus*, and uses this character in a key to genera. Hill (1921), who described Queensland Tabanid larvae more like the European forms than mine, does not mention whether any of the species had the dorsum of the thorax smooth or striated. All his larvae were aquatic.

2. Another peculiar feature of the larvae of *T. froggatti*, *T. gentilis* and *T. neobasalis* is the truncated posterior end. All other *Tabanus* larvae described are pointed posteriorly, most having long siphons. Neave (1915) states that the abruptly truncated siphon is peculiar to the genus *Haematopota*, whilst in *Tabanus* the end of the anal segment forming the base of the siphon is long and tapered. The Australian *Tabanus* larvae figured by Hill and by Johnston and Bancroft (1920) have long siphons.

3. The larvae are definitely terrestrial, specimens of *T. froggatti* and *T. gentilis* even having been taken in quite dry soil, whereas most other known *Tabanus* larvae are aquatic, or at least semi-aquatic. It is possible that the first two peculiar features of the larvae are expressions of their unusual environment.

The Australian species of *Tabanus* fall into two main groups—the bare-eyed group which forms part of the Indo-Malayan element, appears to be related to the old world species, and to which the larvae described by Hill and by Johnston and Bancroft belong, and the hairy-eyed group constituting the sub-genus *Theriotplectes*, which has a more southern distribution and would appear to belong to the Antarctic element of the fauna. It is difficult to find reliable adult characters to justify the separation of the two groups, the hairs on the eyes being exceedingly minute and sparse in certain species. The species described in this paper are typical *Theriotplectes*, and the larval characters discovered support the separation of the hairy-eyed group, at least sub-generically.

## Acknowledgements.

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## DESCRIPTION OF PLATE X.

- Fig. 1.—Slope of Black Mt., Canberra, where the larvae of *Tabanus froggatti* and *T. neobasalis* occur.
- Fig. 2.—Female *T. froggatti* in the act of biting.  $\times 4$  (approx.).
- Fig. 3.—Pupal shell of *T. froggatti*.  $\times 4$  (approx.).
- Fig. 4.—Pupal shell of *T. neobasalis*.  $\times 4$ .
- Fig. 5.—Larva of *T. froggatti*.  $\times 4$  (approx.).
- Fig. 6.—Larva of *T. froggatti* (stained) showing rugose bands.
- Figs. 7, 8.—Larva of *T. neobasalis*.  $\times 4$  (approx.).
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## THE GROWTH OF SOIL ON SLOPES.\*

By J. MACDONALD HOLMES, Ph.D., Professor of Geography, University of Sydney.

(Plate xiii; three Text-figures.)

[Read 28th July, 1937.]

Progress in soil science has been rapid and revolutionary. Changes have taken place, not only in soil description, but in the sources from which the knowledge has been forthcoming. Formerly advances were made through geomorphology, but now they are greatest in the realms of chemistry and biology.

Soils have been divided into mature and immature soils, and for the most part soil science has confined itself to mature soils. This paper deals with the less mature soils which are characteristic of very large areas in eastern Australia.

### *Soil and Slope.*

In any topographic unit, and irrespective of rock homogeneity, such, for example, as a major drainage area, there occurs a series of soils which bear some relation to each other; such a group we have called a *soil assemblage*. In any section of that unit, for example, a valley side, there is a sequence of soils down the slope; such a sequence we have called a *soil succession*. Such succession is characteristic of all "slopes country" and is developed step by step clearly in certain topographic situations. Theoretically the change down the slope, i.e., the outline, is the profile of the land surface in all geographical literature, and that is the English use of the word, though 'profile' is used for an outline of a transverse section of an earthwork showing the thickness at various heights. In soil science, 'soil profile' has been used for what is really 'soil cross-section', i.e., change with depth. ✓ Milne (*Nature*, Vol. 138, No. 3491) comments on this and has used the word "catena" for soil changes down the slope.

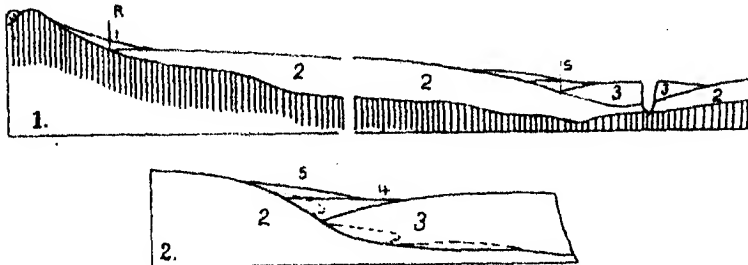
Several diagrams have been prepared to represent such a generalized soil succession for the majority of the inland slopes country of eastern Australia, and more particularly the New England, Tamworth, Mudgee, and Bathurst districts of New South Wales. The overall distance apart of these districts is 250 miles, which makes a region large enough to test the universality of the processes mentioned.

The slope and site factors of these soil groups (Text-fig. 1) are fundamental; one might call it *topographic inertia* in soil formation.

*Group 1 are hilltop soils of increasing maturity.*—They are always stony and shallow, and rock outcrops frequently. Bore materials show a lessened amount of stony material at first, but an increasing frequency towards the parent rock. At shallow depth there is a deepening of colour and apparent increase in clay, but always with grittiness. The deeper layers, after about two or three feet, show surprising fresh rock-fragments. The colours of the hilltop soils vary consider-

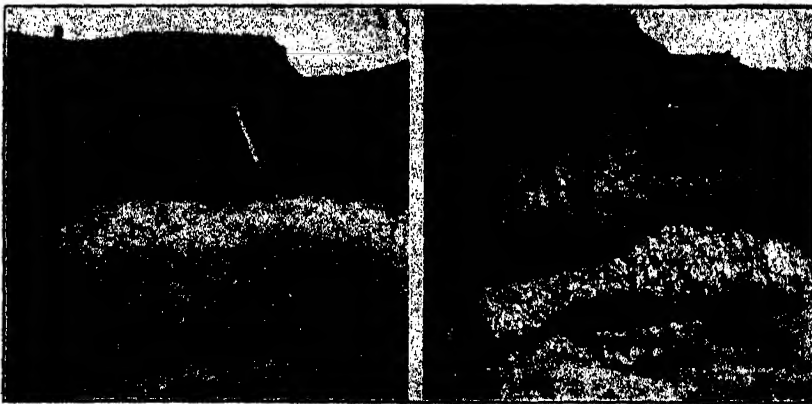
\* Field work in the Tamworth district associated with this paper was made possible by a grant made to the University of Sydney by the Carnegie Corporation of New York.

ably in apparent relation to the immediate parent rock. Shales give grey colours, slates red and brown to almost purple colours, and basalts generally chocolate to black. Since these soils are on hilltops or in exposed positions, colour-spread is common, especially if the area has been ploughed over. Profile characteristics are only slightly developed.



Text-fig. 1.—Soil succession with slope (middle horizontal distance greatly shortened). 1. Immature, stony soil; 2. Red loams; 3. River silts; 4. Black, heavy clay; 5. Light grey clay loam.

Text-fig. 2.—Junction of 2 and 3 (dotted line suggests interdigiting).



Text-fig. 3.—(right) Section represented by Profile 1. Note sharp junction between C.p. and X horizons; (left) Continuation up hill from photograph on right. Top, A2 horizon, then B horizon, C.p. (white), X (columnar), Y (undercut).

*Group 2, in which middle slopes initiate aggregation and differentiation.*—Over much of the Western Slopes of New South Wales and especially on the hills around Tamworth, the characteristic soils are deep, red loams. They form, for the most part, the great wheat-belt soils and some of the best pasture land. These reddish soils vary from chocolate colour, through red to brown and even to light brown. They are often very stony, invariably containing high silty zones, and can frequently be called 'sandy loams'. These "red loams" vary in depth on the upper middle slopes from three to ten feet, and on the lower slopes to greater depths. They form most frequently the convex surface, and often join the neighbouring plain or flood plain in a slight break of slope. Since these slopes are of continuous grade, and because the geological grain is often across country and the dip of

the rocks is frequently at a high angle to the topographic surface, there is considerable variety of colour tone in soils, but not related to the immediate underlying rock type because of past denudation history. In general the darker colours are on the lower aspects of the slope, except where recent rainwash, accelerated by ploughing, has been active and exposed the deeper red-brown horizons, or where the line of a little runnel has accumulated the rainwash of residual light-grey soils. The profiles of these loam soils are complex, colour deepening with depth, and also clay content. At the position of what might be expected to be C horizon, there is increasing stoniness, but on boring deeper this is followed by a fresh increase in clay content, which occurs in different physical condition from the first clay zone. The change in the structural appearance is noteworthy: Profile 1 from Woolomin Parish, Portion 66 (five miles west of Tamworth), can be considered as typical:

*Profile 1.\**

- 0"- 10" A horizons.—Light brown sandy loam.  
 10"- 55" B horizons.—Reddish, then yellowish-brown sandy loam, increase in clay and iron content, gritty, a few gravel zones.  
 55"- 67" C.p. horizons.—Sandy and pebbly, hardened, whitened, very abrupt lower boundary. 53% coarse sand, 24% fine sand.  
 67"- 75" X horizons.—Grey-yellow columnar sandy clay, very distinctive zone. 16% coarse sand, 22% fine sand, clay content higher than above.  
 75"- 87" Y horizons.—Similar to X, less columnar, gravel increasing.  
 87"-107" Z horizons.—Continuation of gravel and clay zone, much compacted, lighter in colour, and a basal zone of fresh slate pebbles, probably underlain by disintegrated shale.

The topmost layer is hardened (other than the immediate ploughed surface, which is loose) and stands out like a kerbstone. The B horizons are looser at first, then more compact, while C.p. horizon is loose again. The chief contrast is in the X horizon where the structure is distinctly columnar with sometimes spaces between the columns, especially in a gully face. The Y horizon is compacted and not columnar, while the Z horizon is often very compact and impregnated usually with lime.

This repetition in the profile is widespread and has not been described before.†

The ordinary terms for description of *depth profile* therefore are inadequate because of this "profile repetition", and we use C.p. for pseudo-C because it is best described as a false C. Further, there is probably something omitted between the C.p. horizon and the X horizon—a likelihood of contemporaneous erosion.

Topographically these middle-slope soils lie as if filling in wide undulations. Frequently the generalized surface is so smooth when ploughed that all evidence of the streams which supposedly brought the material is obliterated. The total situation suggests a wide filling in by sheet wash and under climatic conditions more intensive than at present obtain.

At one time the whole of these slopes were covered with trees, possibly some grassland, and since clearing, perfectly fresh gullies made by new assembly of rain-water and by torrential rain wash have been formed, in some cases cutting

\* The standard notation for A and B horizon differentiation has been used in these profiles, though probably a different notation could be devised for still less mature soils.

† Leeper, Nichols and Wadham, *Proc. Roy. Soc. Vict.*, Vol. xlix (N.S.), Pt. 1, p. 113. "The percentage of coarse sand passes from a maximum of 26 at the surface to a minimum of 14 at 2 ft. and rises again to a second maximum of 23 at 3 ft., below which it falls again."

to a depth of five or six feet, and having a well-formed contributory stream pattern, all having vertical wall sides. These types of gullies can be considered as giving a good cross-section of the soil. At other places somewhat similar gullies, but of an earlier phase, have been filled in and recut to rock level. These later types of gullies can be used to give an indication of the nature of the denudation repetition of the area.

The kind of accumulation that has gone on in these middle slopes and the stratification of the deposits is not found to be happening anywhere in the district at the present time. Further, any easy explanation of delta fan formation is inadequate, as the scale of flattening from the width across the slopes in proportion to the length down the slopes does not warrant such a conclusion. Again, the present lie, convexity, and middle-slope position, and their occupation as wheat and pasture lands make these red loams hazardous soil zones, that is to say, easily erodable when ploughed; this state of affairs in itself suggests instability of lie and a deposition under conditions not now obtaining.

*Group 3, in which flood plains stabilize silt.*—This group of soils occupies a practically flat surface bordering the middle-slope soils and forms river banks, e.g., Peel River and its tributaries. This flood-plain landform occurs on most creeks and rivers in eastern Australia, and the soils thereof are sometimes known as 'lucerne' soils.

Now these flood-plain soils are light brown river silts, dark at top, occasionally interstratified with blacker clay layers, and sometimes a thin pebble or gravel bed. Such soils vary in depth from one or two feet to 15 feet, and are being actively eroded at the present time. Although accumulation is taking place at certain points, nothing comparable to the present soils for their depth is being formed. Also some areas of these valuable dark soils are being deteriorated by down wash and even by cutting from the middle slopes. The deeper layers below the grey-black silts are often reddish, and bear some relation to the middle-slope red loams. The very lowest layers are often of a yellowish to grey-blue clay, underlain by large well-worn river pebbles. The whole profile shows several phases of recurrent deposition in quiet water, but very little of what is usually termed false bedding. Where the middle-slope soils and river-plain silts have been found in close contact, it becomes obvious that the river silts are, in general, a later deposit (Dungowan Creek Section), though sometimes interdigitated.

The upper surface of these flood-plain soils slopes from the present river bank inwards towards the middle slope. The junction zone at the surface is often a depression filled with swampy, black, stiff clays (Text-figs. 1-3). These depressions are rain-wash swamp pools and may coalesce, with the help of occasional ponded-back flood river water, to become miniature creeks. The chief point is that they are filled with stiff black clays, rarely silts. Less frequently a backwater or flood distributary from a river occupies and may have formed this zone.

In the smaller and now almost dry creeks which, for the most part, are widespread throughout the area, and such as occur in the Loomberah and Bective areas (near Tamworth), the flood-plain soils are not dark alluvial, but yellow-brown sands. They have been carried from some distance upstream and deposited against the red loams. The boundary of the soil junction is often difficult to determine, but usually the farmer has planted his fence with some degree of accuracy along it, the red loam being good wheat land, and the yellow sand forming grazing and treed land. Frequently the upper parts of these creeks have been themselves filled in, usually by a very friable, dry, grey, silty loam. This latter soil probably

represents savannah grey soil washed in after extensive clearings of the surrounding country.

*Groups 4 and 5.*—Two other important soil types, not of great extent, have developed in special topographic sites. The black, swampy clay has already been mentioned; partly overlapping it and the middle-slope red loam is a light grey rain-wash soil. These two soils (Text-fig. 2, Nos. 4 and 5) are found between Nos. 3 and 2. The grey soil often forms a "line" up a middle slope where a slight depression occurs, showing that it is superficial, and associated with recent wash and possibly with the former woodland.

The further description of these soils and profiles necessitates structural, mechanical and chemical analysis. This is being done in conjunction with a soil survey at present being carried out in the Tamworth district by W. H. Maze, Lecturer in Geography, University of Sydney.

#### *Slope, Site, and Situation Factors in Soil Description.*

<sup>1</sup> From the previous description it is obvious that more than the immediate first few feet of soil is worthy of attention if even the topmost layers of the soil are to be understood, especially since those less mature soils characterize most, if not all, of eastern Australia.

Now Text-figures 1-8 and Table 1 indicate, in "slopes" country, firstly, that changes in slope set soil boundaries, secondly, that many of the chief properties of a soil type are given to it by its topographic site, and thirdly, that there is a "state of being" in soil, which is not related to the immediate underlying rock, but to the past history of the denudation of the region in which it is found.

The boundaries of soil in any succession are very important from the point of view of mapping, though the precise boundary of the major soil-type is not always observable at the surface. In Text-figure 1, for example, the points R, S, are of extraordinary interest because the changes taking place in the succession and in regional distribution can be so readily observed there. Perhaps the greatest value of these critical points lies in the way in which they lend themselves to speedy soil mapping. At once broad zones of a common "state of being" and of like continuity and behaviour are delineated almost by eye, and certainly with only a few borings.

At point R, in the Tamworth District, there is a line of change of maturity at the surface. This is brought about at first by overlapping downwash and later by gullying and sheetwash as a whole, so that Zone 1 is often being intensively eroded and point R is being moved downhill, with the placing of the lower soil regions of Zone 2 on top of that zone further down. In the past there was soil accumulation in Zone 2 which was expanding uphill. Further, at point R, there is a division of types of surface and sub-surface drainage of the soil.

At point S there are several types of change. If a slight hollow has been left at this point, then a stiff, black swamp clay has formed (soil type 4), but this is being altered at the surface by the formation of a lighter phase (soil type 5), and both may be obliterated by extreme downwash from above (soil type 2) if excessive cultivation has permitted gully erosion in the middle slope. Usually the boundary between soil types 2 and 3 is quite sharp, often with a slight break of slope (Text-fig. 2). With ploughing or excessive grazing, the silts are being overburdened with the coarser fraction of soil type 2, and the boundary is very obscure. These breaks of slope and changes of soil are obviously of great importance in soil-profile formation and in farm practice.

Slope then has this immediate significance, that there are critical points on the slope, usually breaks of slope, which have fixed the soil boundary, and this is easily recognized for mapping purposes with a minimum of profile determination.

Again, irrespective of climate or of vegetation, but having certain modifications for different climatic types, the degree of slope determines the rate of maturing of the soil, steep slopes possessing always immature soils, while more gentle slopes, if undisturbed by human activity, have soils which reach maturity. Furthermore, the nature of the slope may determine the mineral content by continued and selective downwash. On slopes of more than  $10^\circ$  invariably there is permanent immaturity, i.e., indefiniteness in profile subdivision, and a recognizable rock character. On slopes of less than  $10^\circ$  there is something of an equilibrium, less on convex, more on concave, providing there is a fair vegetation covering. On slopes of the order of  $2^\circ$ , especially if forming general concavity, great maturity and high clay content are common. In regions of moderate rainfall, i.e., 20 to 35 inches per annum, we have noted that the clay content increases with distance down the slope, provided, of course, the slope angle is decreasing regularly (Table 1).

TABLE 1.

Land use type	Tree covered, partly cleared.	Cleared for grazing.	Ploughed for wheat and lucerne.	Regular annual wheat crops.	Lucerne growing varying in intensity.
Tree type* . .	white box.	white box-----yellow box-----apple.			river gum.
Soil type (A horizon only)	stony grey sandy loam.	yellow-brown to red-brown sandy loam to loam.		clay loam to heavy black clay.	river silt.
Soil group and slope (as in Text-fig. 1)	steep slopes. Group 1.	middle slopes decreasing to flat. Group 2.		Concave to flat. Groups 4 and 5.	Group 3
Average land value (£A) per acre (if all of one type) . . .	about 1.	as low as 5, increasing to 20.		30 to 60 according to heaviness and uniformity.	

\* White box—*Eucalyptus albens*; Yellow box—*E. melliodora*; Apple—*Angophora intermedia*; River gum—*E. camaldulensis*.

In brief, then, on exposed places, hilltops, spurs and rises, soil is becoming increasingly immature, because of physical mobility. This is a persistent tendency. On middle slopes, soils are aggregates derived from several rock types and from several vegetation formations, all of which have come from measurable and limited areas. This is still true even when there is a general homogeneity of rock type, since the geological history of eastern Australia is very varied.

Flood-plain soils have cumulative and specialized silt characteristics, high humus content, and are re-sorted so that the rock origin is unrecognizable and the clay content is at a minimum. Plain soils in continued liability to flooding are an anomaly in the sense that recurrent floods may alter the maturity or immaturity according as the flood brings down coarse or fine silt, or even soil from a neighbouring zone. Ancient flood plains, not now being flooded, will have a soil-type distribution in relation to their past flooding history and to their lie with relation to the immediate local source of the flood material and to the vegetation developed upon the flood plain. Further, the present method of profile



description is not nearly adequate in view of the repetition and the "arranged" character of most of the slopes and flood-plain soils of eastern Australia. Perhaps the most significant point about slope and soil is that there is a relationship between the soils down the slope, and like slopes have many like properties.

Secondly, much can be said about the soil type from its topographic site. Invariably the red loams lie on the middle slope and have experienced erosion and subsequent accumulation, so that the unconsolidated material shows a repetition, and even the topmost layers frequently exhibit that character. The last major phase has been one of accumulation. This is shown by the fresh nature of the repeated layers and the convexity of the surface as distinct from the concavity of the underlying rock surface. Thus there is a speedier run-off in the "slopes" area than one might expect, a more complete drainage, and although much iron is present, there is rarely an iron pan, and aeration is comparatively high. Thus, in the Tamworth District, for example, the middle-slope soils, which cover the largest area, show accumulated characteristics, repetition in the profile and a "convex lie", a condition of affairs we have called "the state of being".

From the point of view of soil classification and soil behaviour, the recognition of a "state of being" seems more important than determining the underlying rock. These middle-slope soils could be stated to have a false C horizon (pseudo-C), and a mineral content recognizable only from an examination of the soil itself. Is this "state of being" of such universality that all, or nearly all, upper, middle and lower slope soils bear a precise relation to each other, and are characterized thereby, and that a new nomenclature needs to be added to soil science?

From this evidence two major ideas are derived: (1) That the rock debris and mineral content of the soil for most of the Tamworth region have been accumulated from a wide zone and from regions of considerably different geological history; and (2) that the present position of soil on any slope and the nature of that slope are very important factors in bringing soil to its present "state of being" and so contributing largely to the trends for change, both in the surface and in the profiles of the soils. For these reasons any classification has to give prominence to topographical site and slope, and the geomorphological history. After much reconnaissance and trials, we consider that any regional grouping should show (1) soil properties which obtain over all the area or large divisions of it, (2) properties of many of the topographic divisions, and (3) special properties of very limited regions. Bearing this principle of decreasing generalization in mind, the following working schedule gives (from an examination of the soil itself) an adequate basis for soil description and mapping:

1. The "state of being" of the soil (total unconsolidated layer), simple or complex history, the recognition of soil assemblage and soil succession.
2. Evidences in the topmost layers of climatic boundaries (non-lime-forming or lime-forming, degree of podsolization).
3. Boundaries of vegetation formations, or approximation thereto if land is greatly cleared.
4. Recognition of major soil-type boundaries by topographic factor (following on 1).
5. Further subdivision, by regional sampling, especially of topmost layers, on basis of colour, texture and structure (as in standard soil science practice for fully mature soils).

In addition, still further subdivisions or separate units could be made in regard to erodability, behaviour sequence, and other life history and biological properties.

Although this might appear to be much more than is wanted by a soil survey, it is necessary when one comes to inquire into the meaning of physical things and the bearing of one soil type to its neighbour. At any rate, these are the steps as they came to be recognized and their relative importance impressed upon us.

Now the Western Slopes country of New South Wales lends itself to such an examination, but over wide, extensive plains, such a soil description may be immensely more difficult to unravel. Nevertheless, as our observations show, the above categorical schedule would function for some regions more than others, but for practically all of eastern Australia, since eastern Australia is a land of plateaux and uplands, of long, gentle convex slopes and wide valley plains. Further, even in the far western plains (for example, in the Western Division of New South Wales, which is the western half of the State, and what is there would apply to western Victoria, northern South Australia, and south-western Queensland) much gentle convexity is the commonest aspect of the landscape; and it is more than an impression that the wide, extensive red soils characteristic of these western regions bear some relation to this type of slope, especially when contrasted with the equally extensive and slightly concave areas of grey soils, and the less frequent, so-called, black soil plains.

There is some virtue in the above scheme. It lends itself to progressive development with each fresh examination, for the generalized framework remains constant and gains in value as each section of any area becomes more intensively mapped, whether now or in the future.

Further, soil mapping requires to be expedited if it is to keep pace with vegetation mapping and resources mapping generally, not to speak of agriculture and road engineering progress. Soil mapping for resources purposes and for all governmental work should be up-to-date in scientific procedure, but requires only a certain scale of correctness (varying with the type of area), so that all major points and boundaries of groups are fixed and general characteristics established. Detailed soil queries in regard to a particular property will always require visitation, and also in regard to scientific problems, but these are not reasons why all soil work should be suspended until a highly trained staff of experts working a few paddocks per day can traverse Australia. Soil science has proceeded far enough now to allow fresh maps to be prepared by decades, the lesser map incorporated in the greater. Further, whole new sets of facts about climate-topography-soil, these three taken together, are required if farming is to progress, and soil mapping of this more generalized kind is both adequate for description and effective in application.

#### *Some Interpretations.*

In soil as in landform science, many of the observations can only be interpreted. There is no system of absolute proof, since much of the evidence has been removed, and only the result is observable.

Now the most significant feature in these lesser soils, shall we say, is the profile periodicity. More knowledge is needed than we can present here. In the most frequent cases the stony or sandy layer in the middle position occurs only once and we have called it a pseudo-C horizon (C.p.). It would most certainly be mistaken for a C horizon if, say, a four-inch auger were in use. Although the pseudo-C horizon is observable best in the gullies which truncate ploughed

paddocks, the general smoothness of the whole surrounding filled-in middle slope indicates that the repetition must be applied to more than a very localized profile. In several cases these red middle-slope gravelly clays are used by brickworks, and so a wide selection of profiles is easily observable. In other cases road-making operations and well-digging offer similar opportunities.

*Profile 2.* West Tamworth Brickfields.

- 0 - 12". A horizons.—Dark grey to light fawn sandy loam (stony).
- 12"- 30". B horizons.—Yellow to yellow-brown gravelly loams.
- 30"- 32". C.p. horizons.—This is the termination of the B horizon, which makes an abrupt junction with the X horizons below.
- 32"- 41". X horizons.—Dark yellow layer, columnar, ancient plant roots, highest clay content of whole profile.
- 41"- 55". Y horizons.—Red-brown sandy layer, not columnar.
- 55"- 67". Z horizons.—Purple-tinted gritty layer overlying shale.

*Profile 3.* Bective Parish. Portion 100.

- 0 - 12". A and B horizons.—Fine light grey sandy loam.
- 12"- 30". C.p. horizons.—Soil with angular pebbles.
- 30"- 36". X horizons.—Clay and less pebbles, terminating abruptly.
- 36"- 47". Y horizons.—Deposition zone of iron, clay and lime, hardened, also ending in a sharp break.
- 47"- 65". Z horizons.—Fine dark brown sandy clay chiefly, no stony material, columnar.

*Profile 4.* Denistone Station, near Werris Creek.

- 0 - 36". A and B horizons.—Typical black soil, high clay content.
- 36"- 60". C.p. horizons.—Light brown sandy loam ending abruptly in fine gravel.
- 60"- 84". X horizons.—Dark brown soil, columnar, high clay content, lime pipes very well developed, not terminating in decomposed rock since underlain by several gravel and pebble beds.

*Profile 5.* Ploughed area seven miles from Somerton on Gunnedah Road.

- 0 - 6". A horizons.—Fawn sandy loam.
- 6"- 54". B horizons.—Similar to above, darker, slightly columnar.
- 54"- 66". Light brown sandy soil.
- 66"- 72". Soil and pebbles.
- 72"-108". C.p. horizons.—Brown soil ending in a sharp, but undulating line of fine sand.
- 108"-156". X horizons.—Dark columnar, grey-brown soils of river silt type.
- 156"-168". Y horizons.—Silt deposit, conspicuous lime pipe deposition, and large pebbles at the base.
- Z horizons.—Very compacted layer of disintegrated rock, cemented with spongy limestone, has the appearance of an artificially cemented rubble.

*Profile 6.* Mudgee.

- 0 - 12". A and B horizons.—Light brown sandy loam.
- 12"- 24". C.p. horizons.—As above with increase in light gravel and pebbles.
- 24"- 42". X horizons.—Columnar structure, increase in red iron.
- 42"- 60". Y horizons.—As in X, absence of columnar structure, increase in gravel.

*Profile 7.* Bathurst.

- 0 - 34". Brown silty loam, lucerne.
- 34"- 37". Zone of quartz pebbles.
- 37"- 67". Brown silt.

- 67"- 77". Black silt, very noticeable at a distance.  
77"- 97". Brown silt as above, but shaded into by black silt.  
97"-121". Slaty pebbles and silt.  
121"-133". Large pebbles in layers.

The above profiles (2-7), and our observations over the 2,000 square miles of the Tamworth district, the Mudgee, Bathurst, New England, Lake George, and Broken Hill areas, and the region from Adelaide to Tapley's Hill, South Australia, indicated wide universality of the pseudo-C horizon (C.p.). In some cases charred wood remains are present, which indicate that the several feet of soil overlying is of comparatively recent deposition, though before the time of the present tree growth and well before cultivation. Where much accumulation has gone on in the middle slope of recent date, due to ruthless clearing of the upper slope, or for some reason where a new cycle of erosion has commenced, as in the Dungowan Creek (Tamworth) district, the profile shows a very great degree of immaturity and an irregularly mixed character.

The stony or gravelly nature of the pseudo-C horizon indicates a change in the kind and rate of deposition. The layer below the pseudo-C horizon is a stiff clay and may represent an old B, or even an A, horizon, now overlain by several feet of soil which has been long enough in position to have its own A, B, horizons.

Why this change in deposition should have taken place is harder to explain, yet it must have taken place before European occupation of Australia, which in many of the areas under discussion has only become intensive in the present century.

The pseudo-C horizon, the soil-type distribution patterns, their depth in certain areas, and the absence of depth where depth might be expected, and the inability of the present forces to form such soils to-day, suggest past conditions of slope and climate, perhaps of elevation, different from those of to-day. There is recent acceleration of erosion (a new cycle some would call it), apart from that additional erosion brought about by man-made factors of clearing, cultivation, etc. This is confirmed by a statistical examination of erosion on upper, middle, and lower slopes, where many fresh evidences are apparent, by erosion on both banks simultaneously and on the beds of creeks, and by the advance of the hill slope against the flood plain at all re-entrants. Further, there is a general convexity of the aspect of the elements of landscape. This, of course, in addition to the long period of erosion to form the general drainage pattern already mentioned.

It is fair speculation that an examination of the soil profile and the classification of soils as above may give information which will help in the solution of the immediate past climate of Australia and confirm other meagre evidence that Pleistocene times were more pluvial than the present. The periodicity in the profiles and the widespread distribution of deep middle-slope soils, and the extent of the valley floors indicate a greater period of deposition over the area than obtains at present.

The sequence of events from the deposition evidence suggests a development of the landscape over so long a period of time that the stream pattern bears little relation to the geological grain of the country, for example, streams traverse anticlines and synclines indiscriminately (Currahubula Creek, the Peel tributaries). During this period a soil surface was developed. At a very much more recent date, and somewhat cataclysmic in its incidence, increased denudation took place which involved a smoothing of the landscape, greatly increasing deposition eventually on the middle slopes. There was greater flow in the rivers and, as this flow decreased, wide silt plains were built up. This increased

deposition throughout the slopes country was not a single event but a period of events which slowed down. Yet more recently, and accelerated by land usage of to-day, denudation has become revived and is removing the previous widely-spread deposition. It is possible from this evidence that the land was more rugged and at greater elevation than at present, or that, in view of the comparative flatness of the New England area, and other areas in eastern Australia at a high elevation, there was in recent geological times a general uplift of considerable amount, and the effect of this uplift has made itself felt most in slopes country.\*

In early determinations of soil, rock character was given pride of place, and as long as the A and B horizons can be shown to be directly related to a C horizon which is being formed from disintegrating rock *in situ*, then the rock-type name will indicate the soil-type name, and in very immature soils no better classification can be suggested. From the previous discussion, however, it is obvious that the disintegrated rock spreads from one rock type to the next, and in the case of the middle-slope soils, as already stated, the soil type bears little relation to the underlying rock type, and the rocky character of most silt soils cannot be given an immediate origin.

One tendency on slopes is towards uniformity of soil type, since forces making for erosion and transfer are obliterating the distinctions outlined above (Table 1); the grey hilltops merge into the red loams and both encroach on the river silts, which in themselves are being eroded away. This is so not only in the realm of soil but in land valuation. Loams (soil type 2) are valuable wheat soils, while river silts are still more valuable lucerne soils. If erosion continues there will be a general uniformity of soil type and a reduction in value throughout to the lower level (Table 1).

In the Western Slopes of New South Wales, with the initiation of a fresh cycle of activity the natural tendency would appear to be towards increasing immaturity, which is the real issue in soil erosion as distinct from the part played by farm husbandry.

In Text-figure 1, soil types 4 and 5 are a light covering (No. 4 may be three or four feet deep) of more recent soils, and are a continuation of that process of smoothing out the topography which was begun many decades ago, though the greater processes of erosion are going on alongside. This is where the complexity lies, namely, the relative value to be attached to contradictory processes going on simultaneously.

There is still another aspect. In the International Soil Classification, colour is given a high place as a soil indicator, and to a great extent soils are classified on their colours. It has been shown already that the soils in the Tamworth District take their colour to a great extent from their topographic position, the general mass of soils being dark flood soils and red loams, though in the neighbourhood of rock outcrops the rock type may be said to determine the soil colour. For example, shales give grey soils, basalts dark red-brown to black, slates red, granites yellow to brown soils. Where the land has been only recently ploughed there is a thin remnant of colour, probably derived from the nature of the primeval vegetation. Further, the chocolate, red and brown colours are very difficult to distinguish because of frequent ploughing, frequent burning of stubble and especially because lateral soil wash spreads the material from the topmost zone and also frequently exposes the deeper reds and yellows of the B horizon.

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\* W. H. Mace is testing this by making a Slope Variation Map of part of the Western Slopes of New South Wales.

It is this very variety of colour-change which gives many clues to soil behaviour, so that to average the colour for a single paddock destroys the very evidence one requires. The usual method of colour determination as an indicator of soil type when applied to moderately mature soils would appear to be rather ineffectual.

As mentioned at the beginning of this paper, soils must be described from their inherent qualities, and with world-wide possibilities of correlation, yet climate-topography-soil are inseparable, and if soil is to be considered one thing, and not a multitude of different things, they dare not be divorced. Furthermore, climate-topography-soil conjointly are the basis of regional policies of land usage, and perhaps even of farm husbandry—but that argument must await another occasion.

In summary, then, soil can be considered as the end point of landscape development and the idea of growth, separate and contemporaneous, used as a basis of classification. Further, soil types have persistent characteristics due to topographic inertia. Thus do major soil groups become recognizable in the field. In the topographically less stable soils physical change is the most important feature, but in the more stable the chief changes are chemical. These changes, too, vary in given sequences with soil depth, according to the original and accumulated mineral content, the vegetation formation, and the present climatic régime. Thus depth profile gives a further basis for group subdivision, though these profile changes themselves promote soil uniformity over any given climatic region where soil accretion is nil.

Again, if the soil growth be periodic in well-defined stages—a feature observable best in the less mature soils—changes in the type and rate of denudation are indicated. This periodicity may make possible the measurement of changes in tectonic forces and/or long-range climatic succession.

In eastern Australia soils are still forming. In some localities this is recognizable by a planing-off of a convex and still unstable slope and the filling-in of an equally unstable concavity. This smoothing-out of the topography is not likely to be completed since statistical counts of these apparently contradictory processes, in conjunction with hilltop erosion and changes in river behaviour, favour a widespread rejuvenation of the whole denudation processes.

#### EXPLANATION OF PLATE XIII.

The four colour photographs in Plate XIII in conjunction with Text-figure 3 are a pictorial conspectus of the types of country in the Western Slopes of New South Wales. The Dufay Colour Film used has over-emphasized the blue tones, especially in the reflected colour of the river water (Fig. 4); otherwise the colours are typical.

Fig. 1.—Soil cross-section as in Text-figure 3. Shows especially columnar clay zone undercut in middle position and the pseudo-C horizon above it.

Fig. 2.—Typical agricultural occupation on soil group 2. Foreground shows grazing land fully cleared; a few dead trees still stand. Middle distance shows lower convex slope with typical tree types remaining from original open woodland, and young wheat (green). The far middle distance shows a typical low, stony rise, with sufficient soil on it for ploughing, on which high wheat yields are possible in years of good rainfall.

Fig. 3.—A small section of country shown in Fig. 2, representing a convex slope in young wheat, but eroded by gully formation. The A and B horizons in the soil are shown by light and dark tints in the red. This was taken following a good rainy season and the floor of the gully is occupied by weeds. Typical grazing and treed slope in background.

Fig. 4.—This shows the typical lucerne flat bordering the Cockburn River and also the other rivers of the district. The flat nature of the surface is indicated and the depth of silt; the vertical cross-section is typical and is due to undermining and collapse. The surface covering is lucerne. At this point a river flood had carried away much valuable lucerne area, as indicated by the fresh cross-section and the lucerne growing right up to the edge.

For geographical accuracy Figures 1 and 4 should be reversed. They have been processed from the wrong side of the positive colour film.

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being Sir Joseph Prestwich and Professor Boyd Dawkins. At the Leys School Lucas played with the Rugby Football Team with some success—the only recorded instance of his share in any field sports.

In 1883 Lucas was appointed Mathematics and Science Master at Wesley College, Melbourne, the Head Master of which, A. S. Way, had been a boy and Master at Kingswood. The journey across Europe to join the S.S. *Cuzco* at Naples was a belated honeymoon, for he had married in 1882. His brother, Dr. T. P. Lucas, was already in Melbourne, and he was mightily attracted by the prospect of studying a new fauna and flora. The Orient boats then used to coal at Diego Garcia, a coral island in the Indian Ocean, where he went ashore and, characteristically, nearly got left behind through his intense interest in his first coral beach combing. He was rescued by the Orient Manager getting him back to ship and wife in a dug-out paddled by Mauritian natives. Lucas gives an amusing account of the science teaching and equipment at Wesley in 1883. Of course he started a Natural History Society and Museum, making lifelong friends, including Herbert Brookes, who wrote a delightful appreciation of his old Master in the *Wesley College Chronicle* (August, 1936). Lucas was probably the first teacher to introduce Field Study of Nature into a school. Taking an *ad eundem* degree, he became a member of the Melbourne University Senate, and, by his efforts, a motion was carried to establish a separate Chair of Biology, and the appointment of Baldwin Spencer followed. He became President of the Field Naturalists' Club, founded by his brother, and edited the *Victorian Naturalist* for some years. He was a close friend of Baron von Mueller, who presided at a farewell gathering on the eve of his departure for Sydney.

With J. Burslem Gregory, Lucas went for a 200-mile tramp through hitherto untramped country to Wilson's Promontory, collecting plants and shells, after which the Field Naturalists' Club—at Lucas's suggestion—persuaded the Government to proclaim the Promontory a Reserve. The Journal of this Club, which Lucas edited till 1892, is still a model of its kind, while the Club has a membership of 300, with a monthly attendance of 50 to 70.

Besides his school work in the mornings, Lucas engaged in Tutorial work at Ormond and Trinity Colleges at the Melbourne University, and was largely instrumental in the foundation of Queen's College, of which he was Senior Fellow and Tutor in Science, his colleagues being A. W. Howitt, Rev. Lorimer Fison and Professor Dendy. He also found time to work up the Lizards of Australia, to publish papers on the Amphibia and Fishes of Victoria, and to start the Port Phillip Biological Survey. In this he was greatly aided by Baldwin Spencer, and together they persuaded the Ministry to erect a Biological Laboratory at a cost of £10,000. Only after some consideration did he decline Spencer's offer to become Lecturer in Biology; otherwise his course of life would have been materially different from that actually followed. It was at Spencer's suggestion that the "Introduction to Botany" by Dendy and Lucas was written, a work that has been, and still is, in much use amongst students.

From 1892 to 1898 Lucas was Head Master of Newington College, Stanmore, during which period the school enrolment increased by 50 per cent., and a high University honour roll ensued. In Sydney he at once joined our Society, which then had five members who achieved their F.R.S. (David, Haswell, Hill, Maiden, and Wilson). He went on geological excursions with David, and became the close friend of J. J. Fletcher, with whom he explored the wonderful sandstone areas of Sydney and the Blue Mountains. On one of their trips they left Sydney in the

evening, walked 10 miles from Bell, to reach the summit of Mt. King George at 6 a.m.

His first papers in the Linnean Proceedings were mostly on Lizards. Altogether he contributed 14 papers, those of the last ten years chiefly on Marine Algae, of which he was the acknowledged Australian authority. Two papers also were written in conjunction with others. A member of our Council from 1894 till his death (with the exception of two years, 1924-26, spent in Tasmania), he was President 1907-09. His Presidential Address of 1908 is a model of sane pleading for the proper relation of the State to Science, and should be read by those who did not have the privilege of hearing it. In 1909 he set a useful example in laying on the table the MS. of his 'Revised List of the Fucoideae and Florideae of Australia' as a substitute for less concrete matter.

He was specially selected to give the Memorial Lecture to his brother botanist and friend J. J. Fletcher, and his own words on this subject fitly describe himself as teacher: "There is perhaps one word only in which may be summed up both his discipline and his instruction — sincerity. He hated all humbug and shams, but he loved all that is true or beautiful or good in nature, in literature and in human character."

In 1899 Lucas became Mathematical and Science Master of the Sydney Grammar School. Here he worked for 25 years; was acting Head Master during the war years—when Mr. Sloman was at the front—and, after the resignation of Mr. Sloman, in his own right till 1923. As a sideline in 1906 he assisted with the lectures in Geology and Physlography at the Sydney University, during the absence of Professor David. He also, for many years, was Examiner in Chemistry for the Technical College, Sydney.

As a teacher, Lucas possessed a phenomenal versatility of knowledge which, combined with unusual patience, equability of temper, and a genuine love of the young, made him notable in his profession. During his career at Newington and the Grammar School his personal pupils won the medals, given for the best candidate in the University Senior Examinations, in no less than 18 different subjects. One of these fell to a lad who, short of a subject, took up Physiology, and sat in Lucas's classroom during certain hours picking up the intellectual crumbs that fell during the few available spare moments of class teaching.

Besides the Sciences—including Mathematics—Greek, Latin, German, Ancient History, and especially English Literature, came with equal facility, and he would discuss some French verses he had written with the French Master, or compose an English sonnet to illustrate its earlier form. A ripe English scholar, he was especially selected at Wesley to take the Vith Form in English, whom he regaled on a wide range of reading, from 'Ralph Roister Doister' to 'The Ring and the Book'. With a rich fund of quotations, often humorously applied, with a twinkle in his eye, he would poke fun at an entomologist friend with lines from Browning or satirize a piano-playing nuisance with a clever parody on Walt Whitman. In (or about) 1900 he gave, by special request, two memorable lectures before the Teachers' Guild of New South Wales on 'Maximum and Minimum Temperature', with impressive experiments carried out on the platform on steel welding and liquid air respectively. One of the most remarkable fruits of his learning was his linguistic powers. From school he brought a sound scholarship in the classics and French, with some proficiency in German. With little continental travel, or other inducement than the desire for information from foreign books of Science, Lucas set himself to master a difficult language as a holiday pastime. Thus, while spending a summer vacation with him at Twofold Bay, the writer found him

reading Don Quixote in the original Spanish. He acquired Italian in order to study the *'Sylloge Algarum'* of De Toni. He took up Russian in order to read a Russian author on Lizards; and this was no light dalliance, having its practical application during war years, when he was the only available interpreter who could attend a law court and help some Russian refugees in trouble. He also gave a lecture at the school on modern Russian Literature.

With a backward pupil he, on one occasion, not once or twice, but five times, explained the working of a problem in Algebra. When someone commented on his patience he answered simply, "If I hadn't done it the fifth time the other four times would have been wasted." Herbert Brookes says of him, "he had a new way of teaching in those far off days. I question whether any other teacher in Australia has touched so intimately and deeply the lives of so many young Australians", and he quotes as appropriate to Lucas, "Knowledge may be gained from books, but the love of knowledge is transmitted only by personal contact". Of his modesty one may quote his own words on J. J. Fletcher: "His aim was not to be talked about for doing something, but to do something great because it was a fruitful thing to do."

In 1923 he retired from school work, but not to rest. On Professor Carslaw's recommendation he accepted the Chair of Mathematics in the University of Tasmania, as Acting Professor; surely a unique performance for a man of 70. To quote Dr. Prescott, "Few men would have cared, or dared, to take such a responsibility at his age. But in his quiet way he was a daring soul". In November, 1924, he wrote: "It has been an interesting experience, and I have enjoyed the work, though it has been rather strenuous, as I was very rusty. They have asked me to take similar work through next year and I have agreed, but I think I shall be glad actually to begin to rest." Again, in October, 1925, he wrote: "Tasmania has, I believe, rejuvenated me, and I shall part from her, and the folk here, with much reluctance." Amongst these folk were Mr. and Mrs. L. H. Lindon—the former Head Master of Geelong and an old Grammar School colleague—and Mr. and Mrs. Perrin, who shared in his algae hunting. During the last decade of his life Lucas showed his 'rejuvenation' by his active research on the Algae. He wrote the article 'Algae' for the *Australian Encyclopaedia*. With Mrs. Perrin he collected the seaweeds of the Barrier Reef and of Lord Howe Island. As Curator of the Algae he was allotted a special room at the Botanic Gardens. The Commonwealth Government sent him on a special mission to report on the economic possibilities of the seaweeds of Western Australia. Paying a visit to Rottnest Island, by special permission—for this island is wholly reserved as a penal settlement—he stayed for a week in the Governor's quarters and "was driven from point to point of the coastline in the prison van and assisted in the collection by two convicts. These men so enjoyed their association with him that they continued to collect for him and communicated with him afterwards". Such was his power in winning affection from all sorts and conditions of men. "It was the response to his own genuine affection for all humanity, birds, insects and plants. He was, in very truth, one of the world's great lovers and recalls the spirit of St. Francis." (H.B.)

Since the death of his wife, Lucas lived at Roseville with his daughter, Mrs. Cortis-Jones, and her husband. Here he loved to grow the native shrubs, flowers and ferns collected in his rambles. Every summer was spent in Victoria and Tasmania collecting Algae and knowledge to the end. He published classified lists of the Algae of Tasmania, Tropical Queensland and of Australia in general, also of Lord Howe Island. Since his death, Part 1 of 'The Seaweeds of South

Australia' has been issued by the South Australian Branch of the British Science Guild (June, 1936).

In this Handbook, besides enumerating and classifying, with copious illustrations, the Green and Brown Seaweeds, he gives (1) An Outline of the Progress of Phycology in Australia, (2) Hints on Collecting and Preserving Seaweeds, (3) General Notes on the Classes of Sea Plants, (4) The Work of Seaweeds in Nature, (5) The Uses of Seaweeds to Man. In common with many other scientific men—notably with his fellow Linneans David and Tillyard—Lucas was a skilful draughtsman and photographer; and the illustrations of this and other works are from his own drawings or slides.

Alas! he overtaxed his waning strength when, at 83, he faced stormy weather on the rocks of Warrnambool in May, and a cold developed into pneumonia. On the train journey homeward he collapsed at Albury and died in the Albury Hospital three weeks later (10th June, 1936) from heart weakness. A large gathering paid their last homage at the service, held in the Roseville Methodist Church. Here his old schoolfellow and fellow Head Master, Dr. C. J. Prescott, gave an eloquent address. Representatives of every class of the community were there, including many old colleagues in Science and Education and the prefects of the two schools where he had held sway. Eulogistic notices have appeared in the *Wesley College Chronicle* and the *Sydneyian*—in the latter from four sources, and these have been quoted freely in the present Memorial. Perhaps the most outstanding characteristic in him was that self-effacement that sprang from extreme modesty and a humility learnt from his Puritan forbears. "Lucas helps you to believe in Christians", said Mr. Weigall to Dr. Prescott. It was this common heritage, as much as scientific sympathy, that was the bond between Lucas and Fletcher. They were alike in their scorn of material profit. Fletcher's refusal of higher salary or assistance when he considered that the Society couldn't afford it is matched by the refusal of Lucas to accept more than £1,000 a year as Head Master of the Sydney Grammar School, though offered £1,500, for a similar reason. This self-effacement also formed a veil which dimmed the radiance of his work in the public eye. His name does not appear in the Australian *Who's Who*, though its pages are filled with the names of lesser men. The great sacrifice of his medical career in the interest of his brother has been already noted. Other acts of unselfishness were almost every-day features of his life. Here is one that was clearly impressed on the writer's mind at the time. As a rare indulgence, Lucas, together with Fletcher, joined a botanical expedition to Mt. Kosciuszko, organized by the late J. H. Maiden. On the first day, wandering in this floral Elysium, he and Fletcher became separated towards the evening; Lucas—always a poor bushman and, as on Diego Garcia, lost to the world in the worship of Pan—was veritably bushed, and unable to find the camp. He managed, however, to find his way to the Observer's hut on the summit, where he was detained for 48 hours by a dense fog. Unfortunately a returning horseman passed the Maiden Camp that evening, heard that Lucas was lost on the mountain, and spread the news. This obtained headlines in the Sydney evening papers, and an over-zealous cleric took it to Mrs. Lucas. Lucas hastened home to console a harassed wife, giving up a well-earned holiday. Reference has already been made to the Autobiography written in his late years which it is hoped will see the light of publication. Here is told the brave struggle of a gifted lad who, under the rare teaching and example of a splendid father, chose to scorn delights and lead laborious days, careless of reward but ambitious in effort. Some verses written recently by Lucas and quoted in full in the Wesley College article may be given here in part to show the strength of this early influence,

Stow on the Wold, Gloucestershire. 1862.  
 "Of a year of my childhood the scenes I behold  
 Where we lived on the hillside of Stow on the Wold,  
 For its fields and its faces remain with me yet,  
 And the folks and the flowers I never forget,  
 Where the wind blows cold  
 On old Stow on the Wold.

In the white quarries of fossils a store,  
 In the deep railway cuttings a hundredfold more,  
 How the navvies delighted tobacco to spy  
 When they saw the good parson advancing to pry  
 In the clay stiff and cold  
 Of old Stow on the Wold.

For a bargain in fossils the parson was keen,  
 And he knew them, from Cambrian to Post-Pliocene,  
 When he lectured, the Clergy looked wise as they knew,  
 For the Squire in the Chair gave the Clergy the clue—  
 We must Science uphold  
 In old Stow on the Wold."

Some of his friends lamented that his gifts would have more appropriately adorned a University Chair than the Schoolmaster's desk. Yet, while it is clear that he could have filled almost any Chair of Science as efficiently as he did that of Mathematics, he himself was well content to be employed usefully; cheerfully carrying out the drudgery that went with the endless looking over of examination papers—elsewhere described as soul-destroying work; ever holding aloft the lamp of lofty aims and noble ideals. His portrait by Hanke—a tribute of admiration from Old Boys—hangs in the Assembly Hall of the Sydney Grammar School. It is a great thing to have passed on such a record. Few men have earned so thoroughly the title 'scholar' as he whose whole life was spent in the pursuit of knowledge; and this, not to be stowed away in some mental lumber room, but to be utilized to the full for the benefit of his fellow men.

Of his family his daughter Ida married Mr. H. F. Cortis-Jones of the Newington College Teaching Staff; a second daughter, Grace, married Dr. J. O'Keefe. Three grandchildren are living.

As an appropriate ending to the Memorial of a great Linnean I am permitted to quote the spontaneous homage of an eminent Melbourne citizen, whose heart, as well as his hospitable home, was so freely open to the loved teacher of earlier years.

To A.H.S.L.

When at the last, as that great tide of God  
 Sweeps on me with its never ending flow,  
 And I am lifted up and borne along  
 Upon its buoyant breast, as all must be;  
 And gently flung upon some quiet shore,  
 And tranquil inlet of those Happy Isles:  
 There on that golden strand, full well I know,  
 I shall behold that old familiar form  
 Of him I learned to cherish in this life,  
 Bending as was his wont above the weeds,  
 Shaking their beauty forth from foreign dross,  
 And fondling with an earth-begotten love.  
 There shall I join his club of kindred souls,  
 Formed to prospect that other Out-of-Doors.  
 Still, still, he shall reveal to me those dear  
 And precious things, that are not for the mart,  
 To which my untrained eyes are mostly blind.

Herbert Brookes.

H.J.C.

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ON THE IDENTITY OF THE BUTTERFLY KNOWN IN AUSTRALIA AS  
*HETERONYMPHA PHILEROPE* BOISD., 1832.

By G. A. WATERHOUSE, D.Sc., B.E., F.R.E.S.

[Read 29th September, 1937.]

One of my tasks, when in London during 1936, was to ascertain, if possible, the precise locality in Australia at which the species described by Boisduval in 1832 as *Satyrus philerope* was obtained. This name has been applied to a species of *Heteronympha* allied to *H. merope* Fab., 1775. My investigations, however, have led me to the conclusion, as shown below, that the name *philerope* cannot be used for the species to which it has been applied for about 80 years and, indeed, must sink as a synonym of *Satyrus klugi* Guér., 1831.

It is well known that considerable confusion has arisen in regard to the insects obtained during the French voyages in the Pacific during the early years of last century. The localities are often interchanged, and sometimes the specimens collected on one voyage are mixed with those of another voyage. Then, again, different entomologists wrote on different voyages almost contemporaneously. The two voyages which form the basis of this discussion are the voyage of the '*Coquille*' and the voyage of the '*Astrolabe*'.

The only port in Australia touched at by the '*Coquille*' was Sydney, from 17 January to 22 March, 1824. Whilst at Sydney an excursion was made across the Blue Mts. to Bathurst. (*Narrative of Voyage of 'Coquille'*, Vol. 1, p. 240, by Lesson.) The butterflies of this expedition were first figured in colour on Insect Plates 13 to 18 in the years 1830 and 1831. The figures on the plates are very good, and there is no difficulty in recognizing the species. The names are given at the bottom of the plates and the new species are attributed to Guérin. The text was not published until 1838, when the descriptions are given in *Zoology* II, pt. 2. On page 272 Guérin states that Boisduval had at his disposal the specimens from the '*Coquille*'.

In Australia the '*Astrolabe*' called at King George's Sound, 7-25 Oct., 1826; Western Port, 12-19 Nov., 1826; Jervis Bay, 26-29 Nov., 1826; Port Jackson, 1-19 Dec., 1826; Hobart, Tasmania, 16 Dec., 1827, to 5 Jan., 1828. The butterflies were described by Boisduval in 1832 and, in addition to the species collected on the voyage of the '*Astrolabe*', he included species from other French voyages and the species described by Fabricius, Donovan, Leach, W. S. Macleay and others. He indeed produced a descriptive catalogue of the butterflies of the South Pacific as then known. In the text he mentions all the Pacific species of Guérin, figured on Plates 14, 15 and 16, using Guérin's names excepting *Argynnis gaberti*. He credits the names to Guérin, but does not quote the plate or figure. Of the figures on Plate 13 of the '*Coquille*', Boisduval mentions *coritus* and *poeta*, both of which he attributes to Guérin. It is an open question whether he actually saw these plates of the '*Coquille*' before he wrote the '*Astrolabe*' text or the specimens in the Paris Museum labelled by Guérin. I believe the first to be the case. Then, while

the catalogue of Boisduval was in the press, Plates 13, 14bis, 17, and probably 18 were published. The species on these plates are referred to in an "Avis", a page inserted, without pagination, just after the title page. Here Boisduval identifies some of his new species with those figured by Guérin on these plates, and says *S. klugi* Guér. is the same as *S. phileropé* Boisd. He mentions that he had seen in the Museum the specimen of *cleotas* labelled *poeta* by Guérin, and is at a loss to understand why Guérin changed the name. When the text of the '*Coquille*' was published in 1838, Guérin used the names given by Boisduval in preference to his own. On page 279 he gives *S. phileropé* Boisd. with *S. klugi* Guér. as a synonym.

On placing the above before Mr. F. Hemming, he gave it as his opinion that, as Boisduval himself had stated that his *S. phileropé* was identical with *S. klugi* Guér., the name *phileropé* must sink to *klugi*. This is confirmed by Guérin in 1838, and there seems to be no doubt that both Guérin and Boisduval saw the types. In all cases where the new species were given as identical in the two voyages by Boisduval, it should be noted that the name given by Guérin now takes precedence, excepting in the case of *klugi* and *phileropé*, the name *phileropé* being applied to a *Heteronympha* and not used as a synonym of *klugi*. Also, if Plate 17 of the '*Coquille*', on which *klugi* is figured, had appeared earlier, Boisduval would have adopted that name in place of *phileropé*.

It was then necessary to examine all the specimens that may have been obtained during the voyages of the '*Coquille*' and the '*Astrolabe*'. Fortunately, many years ago the Boisduval collection had become part of the Oberthur collection which, in 1927, was purchased by the British Museum of Natural History. The old specimens labelled *klugi*, *singa* (the male of *klugi*) and *phileropé* were carefully examined, as well as five specimens from the Paris Museum, sent by M. F. le Cerf, who said that beyond these five specimens there were no other specimens unquestionably taken on the voyages of the '*Coquille*' or '*Astrolabe*'. Photographs of the labels in the British Museum were taken by Mr. N. D. Riley and submitted to M. R. Oberthur and M. F. le Cerf for their opinion on the handwriting.

It remains to be seen how the name *phileropé* came to be used for an Australian species of *Heteronympha*. These species are all single brooded and have very definite times of appearance on the wing. The following are pertinent to the discussion.

*Satyrus klugi* Guér. first appears on Insect Plate 17, fig. 2, 1831, in the '*Coquille*' Atlas. No sex is stated, but the figure is of a female and must have come from the Blue Mts., as the figure agrees best with my series from there.

*Satyrus singa* Boisd. is described from a single specimen in the '*Astrolabe*', p. 146, 1832. This is a male and the other sex of *klugi*. It, no doubt, came from near Sydney as, with the exception of Hobart, the other ports of call by the '*Astrolabe*' were too early for it to be on the wing. It is stated to resemble *merope*, and no ocelli are mentioned on the underside of the hindwing. There is a male in the British Museum labelled *singa* B.d. nll. holl., in what I believe to be Boisduval's writing, to which has been added, at a later date, *klugi* Gr. This is without doubt the holotype male of *singa*.

*Satyrus phileropé* Boisd. was described in the '*Astrolabe*', two pages after *singa*, and is also stated to have a great resemblance to *merope*. The Latin and French descriptions do not quite accord. There is one ocellus on both wings on the upperside and on the underside of the forewing in the male, but the Latin description seems to suggest no ocellus on the underside of the hindwing, and the

French two ocelli. The female has definitely one ocellus on the upperside and underside of the forewings and two ocelli on both sides of the hindwing. The types are not available and are probably lost. Boisduval states in the "Avis" that this species is the same as *S. klugi* Guér.

When the text of the '*Coquille*' appeared in 1838, Guérin adopted the name *philerope* Bois. (Zoology, Vol. II, pt. 2, p. 279) and placed *klugi* as a synonym and copied Boisduval's Latin description only, giving the locality as near Port Jackson. Guérin also used Boisduval's names for other species in preference to his own.

In the Voyage of the '*Favorite*', Suppt., Pl. 3, Feisthamel gives a good figure of the male of *singa*, which is correct. Boisduval's description is copied, but the third word "fuscis" of the Latin description is inadvertently omitted. Regarding *philerope*, of which a figure is also given on Pl. 3, Boisduval's Latin description is copied, but the French is considerably altered. The male description does not refer to the *Heteronympha*, but the female description and figure certainly do. The figure is stated to be of a female variety, but it is a normal mainland female. On p. 16 the '*Coquille*' figure of *klugi* is incorrectly said to be a male.

In *Annals Magazine Nat. Hist.*, (3), xix, p. 125, 1867, Butler considered *philerope* Bois. to be a composite species, and incorrectly calls the '*Favorite*' figure of *philerope* a male. He then describes and figures what he considers the female *philerope*. His figure, description and the specimen still in the British Museum show it to be the female of *H. merope duboulayi* Butl., 1867. In a note to his male he states: "Dr. Boisduval, Guérin and Westwood have agreed in considering this to be the female of *klugi*, which belongs to another genus".

In his Catalogue of the Satyridae in the British Museum, 1868, Butler still considers *philerope* Boisd. a composite species (p. 100 and p. 166) and still considers the '*Favorite*' figure a male.

It will be seen from the above that there has been considerable confusion and the sex of various specimens has been incorrectly given. The puzzle is cleared up when it is seen that Guérin and Boisduval, and certainly Feisthamel, incorrectly considered the '*Coquille*' figure of *klugi* a male.

The specimens examined in London were as follows:

1. The holotype male *S. singa* Boisd. from the Boisduval collection, now in the British Museum.
2. A male from the Paris Museum with an old label by H. Lucas *singa* Bdv. This may be the original of the '*Favorite*' figure. It, like No. 1, is the male of *klugi*.
3. A female in the British Museum from the Boisduval collection with a label *Philerope* B. nle. Holl. This is not in the handwriting of Boisduval. It may be the specimen figured in the '*Favorite*' and is the female of the *Heteronympha* from the mainland. It has been incorrectly considered the allotype female in the British Museum.
4. A male of the Tasmanian race of the *Heteronympha* in the British Museum from the Boisduval collection with a label n. holland and a manuscript name in Boisduval's writing.
5. A female in the Paris Museum of the same race as No. 4 with the same manuscript name in the handwriting of H. Lucas.
6. A male from the Guenée collection in the British Museum with a label *Satyrus klugi* Guér. which is almost identical with No. 4 and is not *klugi* Guér. The label is in the handwriting of Guenée.

The available data as set out above lead to certain conclusions.

There is no evidence to show that the butterfly at present called *philerope* is really Boisduval's species. No example has been found in the Boisduval collection nor in the Paris Museum so labelled by him. Boisduval's description of his male *philerope* agrees better with the female of *klugi* in having one ocellus on the hindwing above and the colour of the hindwing below. Both male and female of the *Heteronympha* have two ocelli on the hindwing above, excepting in two specimens. The wavy lines are not black in the *Heteronympha* but, when they are present, are black in the female *klugi*.

It is my opinion that *philerope* Boisd. has for its male the female *klugi* and for its female either the male or the female of the *Heteronympha*. This will explain why Boisduval considered his *philerope* the same as *klugi* Guér. and also Feisthamel considering his figure of *philerope* to be a variety.

Since *philerope* is not a valid name, the *Heteronympha* that has for a long time borne that name requires a name, which is given below. The synonymy of the species concerned is also given.

#### XENICA KLUGI Guérin.

*Satyrus klugi* Guérin, 1831, Voy. Coquille, Atlas Plate 17, fig. 2 (female); *S. singa* Boisd., 1832, Voy. Astrolabe, Lep., p. 145 (male); *S. philerope* Boisd., 1832, l.c., p. 147 (part. female as male); *Xenica klugi* Guér., Waterh. and Lyell, Butterflies of Australia, 1914, p. 44, figs. 137, 138, 825 (males); *X. klugi* Guér., Seltz Macrolep., 1911, Vol. ix, p. 304, Pl. 93c.

This is one of the commonest Satyrids in Australia. It is found from southern Queensland throughout N. S. Wales within 150 miles of the coast, Victoria, South Australia, and coastal Western Australia. In more southern localities it occurs near the sea. It is also plentiful in Tasmania. I have recently examined more than 300 specimens, and in only two cases do I find a subapical ocellus on hindwing above. Although the two ocelli are present below, they are usually indistinct. This species does not show any marked geographical variation, but specimens from Western Australia are usually smaller than those from the east. The type locality is the Blue Mts., N. S. Wales.

In Western Australia an allied species, *X. mynas* Waterh. and Lyell, 1914, is found. It has the dorsum of forewing above yellow instead of brown-black. It is found earlier in the year than *klugi* and shows marked geographical variation.

#### HETERONYMPHA PENELOPE, n. sp.

*H. philerope*, auctorum; *Satyrus philerope* Boisd., 1832, female only; *H. philerope*, Butl., 1867, male only.

The male of this species can be readily recognized by the prominent sex mark occupying more than the basal half of the cell of the forewing above and reaching a prominent black cell spot. In bred specimens this sex mark is black, but it becomes duller with age. The upperside of the forewing is black with orange spots and a subapical ocellus. The hindwing is orange with termen and a short band beyond cell black, a prominent subternal ocellus and a variable smaller subapical ocellus. Beneath, the forewing is paler than above, with apex darker and with black spots, but without the sex mark so that the black cell spot is very conspicuous; a ringed subapical ocellus. Hindwing orange-brown with three red-brown wavy lines; a prominent ringed subternal ocellus and a smaller ringed subapical ocellus.

The female is somewhat similar to the male, but without the sex mark; there is a black basal streak in cell and another below cell. The spots above are usually

paler and smaller, that between the apex and subapical ocellus of forewing usually much darker. Ocelli as in male. Beneath, somewhat similar to the male, with the apex of forewing and the hindwing with a violet, pinkish or yellowish tint. The anal angle of the hindwing is slightly produced and the termen of hindwing wavy in Australian specimens.

Both sexes have a general resemblance to *H. merope* Fab., but it has not so extensive a range. It is found in the mountains of N. S. Wales and Victoria. Also at an altitude and at sea-level in Tasmania. It has not been found in South Australia or Western Australia as stated in Seitz, Vol. ix. It has developed races both in Australia and in Tasmania. It has only one brood and rarely appears on the wing before the middle of January. My earliest dates are Dec. 30 from near Dorrigo, N.S.W., 4,800 ft.; Jan. 23 from Hobart and Cradle Mt., 2,000 ft., in Tasmania. I have examined 50 specimens from N. S. Wales, 40 from Victoria and 40 from Tasmania.

The types of all the races are in the Australian Museum, Sydney.

*H. PENELOPE PENELOPE*, n. subsp.

*Satyrus philerope*, Feisthamel, 1839, Voyage Favorite, Suppl., p. 16, Pl. 3, fig. 2, female; *H. philerope*, Waterh., What Butterfly is That?, 1932, Pl. xv, fig. 4A, female.

This is the largest race. The male is much brighter than specimens from Victoria. The orange spot at end of cell of forewing is separated from the large subdorsal spot by a black bar; the subapical ocellus of the hindwing is sometimes without the white pupil. Beneath, the apex of forewing and the hindwing orange-brown, the remainder of the forewing yellow-brown with black spots; ocelli prominent.

The female above is much darker than the male and the spots are smaller and paler. The basal streaks in and below the cell of forewing are well defined, as is also that of the hindwing; ocelli as in male. Sometimes there is an additional small ocellus in area 5 of hindwing. Beneath, the markings as in male, but the apex of forewing and the hindwing usually with a purplish or pinkish tint of varying intensity, rarely yellowish-brown.

I have found this race commonly at Barrington Tops during the latter part of January and early in February. It was not seen during a visit in the middle of December. Holotype male, allotype female and paratypes are from this locality. I have a few specimens from New South Wales from Stonehenge (Mar.); Ebor 4,800 ft. (Dec. 30); Blue Mts. (Feb., Mar.); Moss Vale (Apr.) and Mt. Kosciuszko 5,000 ft. (Feb.).

*H. PENELOPE STEROPH*, n. subsp.

*H. philerope*, Waterh. and Lyell, 1914, Butterflies of Australia, figs. 112-4, figs. 99, 116 aberrations; Waterh., What Butterfly is That?, 1932, Pl. xv, fig. 4, male.

The male of this race is shaped like that of the previous race, is smaller, the orange on the upperside is paler, and the spot at end of cell of the forewing is usually connected with the large subdorsal spot in 1a. The subapical ocellus of hindwing is small and in one case absent. Beneath, the colour is not so deep as in the typical race nor is there so much difference between the basal two-thirds of the forewing as compared with that of the hindwing. The figure in 'What Butterfly is That?' is much too dark.

The female has the spots of the upperside the same shade or darker and larger than those of the typical race. The spot between the apex and the subapical

ocellus of forewing above is darker than the other spots. Beneath, the purplish or pink tint is not so pronounced, most specimens having the apex of forewing and the hindwing yellowish-brown. The female has a greater resemblance to the male than is the case in the typical race. Several melanic specimens are known.

Holotype male, allotype female and paratypes from Gisborne, Victoria, where it is usually common from Jan. to March. I have it also from Fern Tree Gully.

*H. PENELOPE ALOPE*, n. subsp.

This is a still smaller race in which the black of the upperside is still further reduced. Both males in the Museum are without the subapical ocellus on the hindwing above. Beneath, the general colour is yellow-brown. I have only seen one female which approaches the more eastern Victorian race. It has a pale spot below the subapical ocellus of forewing above, a character sometimes found in females from Gisborne. Beneath, the spot below the subapical ocellus is almost white and the hindwing has a faint tint of purple. The ocelli are proportionately smaller than in *sterope*.

Two males and one female from Lorne, Victoria, in February and March.

*H. PENELOPE DIEMENI*, n. subsp.

This race resembles *sterope*, but the forewing is not so narrow nor the apex so pointed. The anal angle of the hindwing in the female is not so drawn out as in Australian specimens. It is also smaller.

In the male the spots above are not so bright as in the mainland races, the pale spot at end of cell of forewing is not connected to the large subdorsal spot in holotype but is connected in four of the fifteen males before me from the type locality. On the hindwing the subtornal ocellus is prominent, but the subapical is small, without a pupil in the holotype, in two specimens it is absent and in six specimens an additional small ocellus is present in area 5. Beneath, this race is paler than the others, being yellowish-brown with the wavy lines on hindwing indistinct.

The female resembles the male much more than in the other races and has a cream spot below the subapical ocellus of forewing above. Two of the three females from the type locality have the underside of the hindwing yellowish-brown, the other suffused purple.

I have used the name *diemeni* as it was on some of Boisduval's labels on his Tasmanian specimens.

Holotype male, allotype female and paratypes from New Norfolk near Hobart in February; also from Hobart, Jan. 23; Mt. Wellington, 2,000 ft., in March; Dunally and Maria Is., in Feb.; I also place here a female from Launceston (Feb.) and a poor pair from Burnie (Mar.).

*H. PENELOPE PANOPE*, n. subsp.

This is the smallest and darkest race of all, and I have only males before me. On the upperside the orange spots are reduced in size and the spot below the subapical ocellus of the forewing is almost white in most specimens. Seven of the eight males before me have an additional ocellus in area 5 of the hindwing, and these both have a white pupil. On the underside the ocelli are well defined and are ringed and are the same number as above, the pale spot below the subapical ocellus of the forewing is even more prominent than above. The general colour of the apex of the forewing and the hindwing is reddish-brown. In the forewing the apex is less acute and the termen more bowed than in the Australian races.

Eight males from Cradle Mt., Tasmania, 2,000 ft., in January, and one male from Mt. Magnet, also in January.

## NOTES ON AUSTRALIAN MOSQUITOES (DIPTERA, CULICIDAE).

PART III. THE GENUS *AEDOMYIA* THEOBALD.

By I. M. MACKERRAS, M.B., Ch.M., B.Sc.

(Five Text-figures.)

[Read 29th September, 1937.]

The genus *Aedomyia* includes a small number of rare, ornate species, well separated from other genera, and forming such a compact group that at one time African, Oriental, and Australian specimens were all included in one species. Edwards (1929), however, recognized four species, one South American, two African, and one common to the Oriental and Australian regions. In the present paper, a fifth species is recognized, the distribution of the genus being: *A. squamipennis* Arrib. (South America: British Guiana), *A. africana* Nev.-Lem. (Africa: Uganda, Nyasaland), *A. furfurca* End. (Africa: Kamerun, Dar-es-Salaam), *A. catanticta* Knab (Oriental: widespread; Australia: Northern Territory, Queensland), *A. venustipes* Sk. (Australia: New South Wales).

*AEDOMYIA CATANTICTA* Knab.

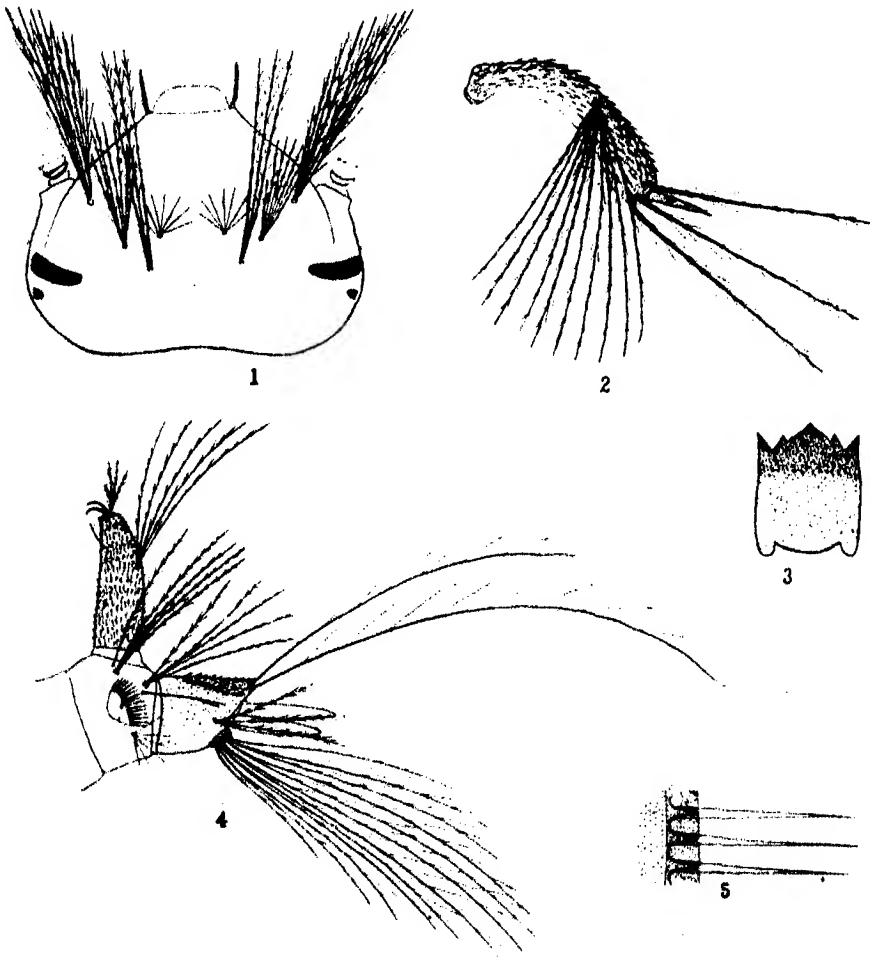
Several adults were bred from larvae collected at Eldsvold, South Queensland, in April, 1924. They agree with previous descriptions (Taylor, 1916; Edwards, 1924; Barraud, 1927), and I have no doubt that they are identical with the true Oriental *A. catanticta*. The larvae were collected in an extensive swamp, and were extremely difficult to find, as they were almost transparent, pale green in colour, and clung tenaciously to the aquatic vegetation (*Nitella*). In captivity, they were observed to cling for prolonged periods to the smaller stems of the plants, from which they evidently obtained their oxygen, as they only came to the surface when dislodged by violent shaking or stirring. Thus, in habits, as in general morphology, these larvae resemble those of *Mansonia*, with which they are sometimes associated (Edwards, 1932). Predaceous insects were extremely abundant in the swamp, but seemed to have little or no effect on the *Aedomyia* larvae.

The general appearance of *Aedomyia* larvae is very striking and characteristic. They may be readily recognized with the naked eye by the extraordinary length of the thoracic and abdominal plumes, and by the enormously swollen antennae. In addition, the structure of the antennae, the very large, unusually formed, pendulous palpi, the absence of a pecten on the siphon, the peculiar structure of the comb on the eighth abdominal segment, and the presence of soft hairs dorsally on the anal saddle, are characters which, so far as I can determine, are found in no other larvae. The presence of a pair of hooks at the tip of the siphon is also rather characteristic, but similar hooks also appear in the genus *Taeniorhynchus* and in certain species of *Culex* (*C. basicinctus* Edw., and others). They are evidently an adaptation to a clinging habit, and have been



evolved independently in the different groups, for the bristles which are modified to form them are not the same in all species.

The larvae of *A. catanticta* from India have been described already by Barraud (1923), but the Queensland specimens do not agree entirely with his description and figures, so it would seem well to figure them and give a short description. Antennae with all three terminal bristles of approximately equal length, and all plumed; antennal plume consisting of ten plumose hairs all markedly longer than the shaft of the antenna. Post-antennal hairs arranged in an oblique row of three on each side, with a stellate tuft of seven or eight short hairs lying anterior and slightly medial to the inner of the three; outer tuft consisting of nine long, dark, heavily plumose hairs; middle tuft of six or seven



Text-figs. 1-5.—Full-grown larva of *A. catanticta*. 1. Head, 2. Antenna.  
3. Labial plate. 4. Terminal segments. 5. Comb.

hairs, which are pale in colour, about half the length of the outer, and finely plumed; inner tuft composed of three stout, long, dark, heavily-plumed hairs. Siphon uniformly covered with short, soft hairs, which are not specially developed on any part; siphonal tuft composed of five or six plumed hairs; siphonal index approximately 3. The three more dorsal hair tufts on the eighth segment are plumed, as is the tuft of three hairs arising from the saddle of the anal segment.

The Indian larva described by Barraud differs chiefly in that the hairs composing the antennal tuft are shorter, being noticeably shorter than the shaft of the antenna; the apical hairs are, however, similar. One cannot tell from the description whether the post-antennal tufts are similar or not. The characters of the terminal segments appear to be similar, though this would not be apparent from a study of the drawings alone. There are certainly no recorded differences of sufficient magnitude to warrant separating the Australian form specifically from the Indian.

#### *AEDOMYIA VENUSTIPES* Skuse.

The type of *A. venustipes*, a female from Elizabeth Bay, Sydney, remains unique; it appears to be somewhat faded, but is in quite good condition. The late Dr. R. J. Tillyard collected some *Aedomyia* larvae in National Park, N.S.W., in February, 1917, which are presumably referable to this species, but I have been unable to rediscover it in this or any other locality.

Taylor (1914), after examining Skuse's types, considered that the Queensland species was the same as *A. venustipes*, and Knab's name, *catasticta*, has since then been regarded as a synonym. A comparison of the specimens from Eidsvold with Skuse's type, however, showed differences, which warrant specific distinction, particularly as they are in characters that are quite constant in the Eidsvold series. The two species may be separated as follows:

- A. catasticta* Knab.—Wings with four large, white costal spots, the third from the base oblong and extending half across the field of the wing. Abdomen brown; with a pair of round, subapical spots on tergites 3 to 6; with narrow lateral zones of yellow scales on the third and subsequent segments, expanding right across the apical edge of the eighth segment; and with a pair of oblique white patches on the basal half of each segment. Second, third, and fourth segments of hind tarsal black, with broad basal and narrow apical white rings (together forming a series of broad white rings on the legs); fifth segment white, with the apex narrowly black.
- A. venustipes* Skuse.—Wings with only three small, rounded costal spots. Abdomen brown, irregularly mottled with creamy scales, which do not form any definite pattern; there are no prominent yellow markings. Second segment of hind tarsus similar to the above, but with the pale rings narrower; third segment entirely pure white; fourth white, with a narrow brown apical ring; fifth black, with a narrow white basal ring.

The larvae from National Park differ from those of *A. catasticta* in several respects. The middle of the three post-antennal hair tufts consists of eight plumed hairs, which are as long and as prominent as the outer and inner. The inner hair tuft is composed of six or more, never less, plumed hairs, which are as long as the other tufts. The siphon is distinctly longer and more slender, the index being 3.5 or more. If these larvae are really those of *A. venustipes*, and it is reasonable to suspect that they are, their characters support the specific distinction from *A. catasticta*.

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## THE PETROLOGY OF THE HARTLEY DISTRICT. IV.

### THE ALTERED DOLERITE DYKES.

By GERMAINE A. JOPLIN, B.Sc., Ph.D., Department of Geology,  
University of Sydney.

[Read 29th September, 1937.]

A study of the petrology of the Hartley District is incomplete unless mention be made of the numerous basic dykes that occur in the area.

In an introductory summary of the general geology of the area (Joplin, 1931), these dyke rocks were erroneously referred to as keratophyres. At that time only two specimens had been sectioned, and they contained albite and quartz. The writer was thus misled in considering them to be acid alkaline rocks. It is now known that the albite is deuteric, that the quartz grains are xenocrysts, and that the rocks have no affinities to the keratophyres.

#### *Field Occurrence.*

The dykes are very numerous and appear to form a swarm which invades members of the plutonic complex and the hornfelses of its contact aureole. They are rarely more than four feet in width and often considerably narrower, and the length of any single continuous mass is usually less than sixty feet, though side-stepping is frequent and several discontinuous outcrops may extend for longer distances.

The dykes follow prominent joint directions in the igneous or metamorphic rocks and they usually have plane parallel sides bounded by the joints in the country rocks. In such cases there is little doubt that the method of intrusion has been simple displacement or the widening of the joint fissure. There are a few dykes, however, notably one behind the Royal Hotel and a smaller one on Moyne Creek, which show transgressive relations and some evidence of stoping, and it is apparent that the igneous mass has come into its present position partly as the result of replacement of the country rock (Culey and Joplin, 1937).

The dykes that have been studied petrographically occur on Campbell's Creek and its eastern tributary, on the River Lett and its tributary behind the hotel, and on Moyne Creek. Others, however, are known to outcrop on Grant's Creek and south-west of Cox's River on the property of Mr. Chris. Commens. Frequently the dykes are much altered and appear as elongated masses of dark soil or as spheroidally weathered boulders.

#### *Petrography.*

In the hand-specimen the rocks are fine-grained and often somewhat stony. They vary from dull green to dark grey, the colour depending on the amount of chlorite present. Occasionally small pink phenocrysts of plagioclase are visible and specks of pyrites and calcite are not infrequent. Many of the dykes, especially

the one behind the hotel, contain xenocrysts of quartz and felspar (Culey and Joplin, 1937), which are usually about 2 mm. across, but may measure half an inch or more.

Under the microscope the rocks exhibit a variable grainsize, and consist of plagioclase phenocrysts in a groundmass of plagioclase, augite, iron-ore, brown hornblende and sometimes a little biotite, apatite and quartz. Chlorite, carbonates, sphene, haematite, prehnite and a zeolite may occur as deuteric minerals.

All the dykes have suffered deuteric alteration, and a single intrusion may show varying degrees of, and a patchy distribution of, the alteration.

The rocks are slightly porphyritic and the groundmass may be intersertal and/or subophitic or intergranular. In some cases the phenocrysts and larger feldspars of the groundmass occur in a mass of chlorite and the rock has the appearance of a fine-grained porphyritic volcanic rock. This peculiar type, however, is associated with the normal rocks and appears to represent an advanced stage in the alteration of the groundmass.

Tabular phenocrysts of plagioclase measure 1 to 2 mm. and are often twinned according to the Carlsbad and Albite laws. In most cases the phenocrysts show incipient albitization along cleavage cracks (Bailey and Grabham, 1909), and the whole phenocryst is often entirely replaced. The original composition of the felspar appears to have been labradorite ( $Ab_{40}An_{60}$ ). The phenocrysts not only show alteration to albite, but also to chlorite and/or calcite, and the chlorite may occur in selective zones in the felspar. The small plagioclase laths in the groundmass are andesine, varying in composition from  $Ab_{60}An_{40}$  to  $Ab_{57}An_{43}$ , and are often altered to chlorite.

Augite occurs in stout prisms or rounded grains measuring up to 0.3 mm. These often mould the feldspars, but may occur in small independent grains. The pyroxene is pale green in colour,  $Z \wedge C = 40^\circ$ , and multiple twinning is often developed.  $2V$  is small, but hardly small enough to justify the assumption that the pyroxene is approaching enstatite-augite. The mineral shows alteration to carbonates, chlorite or an amphibole, the two first being the more common. In many of the altered rocks no pyroxene is present at all, but its original presence is suggested by masses of carbonates and chlorite.

Brown hornblende is present only in the less altered types and occurs only in small amount. It forms slender idiomorphic prisms measuring 0.3 mm.  $X$  = pale yellow,  $Y$  = pale brown,  $Z$  = dark brown ( $Z > Y > X$ );  $Z \wedge C = 17^\circ$ . It is optically negative and the elongation is positive.

Biotite is occasionally present in small brown flakes, and contains lenses of prehnite (Joplin, 1936). Iron-ores are abundant in small rounded grains or octahedra and their form suggests magnetite, but the percentage of titania in the analysed rock indicates that it is probably a titaniferous magnetite; moreover, sphene is a common alteration product.

Chlorite varies in amount. In the less altered types it may be seen filling cracks and fringing pyroxenes and often replacing certain zones in the plagioclase phenocrysts. In the more altered types the rock may be almost completely chloritized and appears distinctly green in the hand-specimen. More than one variety of chlorite is present, but the rocks are very fine-grained so that the chlorites cannot be separated and their refractive indices determined. A variety commonly associated with augite, however, has a yellowish-green colour, is optically negative, the elongation is positive, and the interference colours are low first order. It thus appears to be a variety containing very little alumina and a large proportion of iron and magnesia. Masses of chlorite, showing the characteristic ultra-

blue of pennine, seem to have developed from the feldspars of the groundmass. The rocks often contain solution-cavities filled with this mineral in association with carbonates and sometimes with a zeolite.

Apatite is very sporadic in its development. In some rocks it is entirely absent, and in others is quite abundant and occurs as slender prisms or needles included in the minerals of the groundmass.

Quartz occurs either as xenocrysts which show corrosion, or as a released mineral among the alteration products. It seems unlikely that any of the quartz is of primary consolidation.

Some of the rocks are more albitized than others; in some there is a greater abundance of carbonates or of chlorite, and it is evident that widely different results would be obtained if these extreme types were analysed. All types, however, show characteristic deuteric alteration, and in the rock chosen for analysis (column I below) no one of these processes has gained ascendancy over another.

Although the alteration of the Hartley rock is deuteric and characteristic, it is too altered for the norm to serve any useful purpose.

	I.	II.	III.	IV.	V.
SiO <sub>2</sub> .....	48.84	48.02	48.07	50.60	49.50
Al <sub>2</sub> O <sub>3</sub> .....	18.59	18.03	19.02	17.40	14.37
Fe <sub>2</sub> O <sub>3</sub> .....	5.75	7.17	7.65	4.57	6.55
FeO .....	4.80	2.78	4.83	0.29	5.84
MgO .....	3.89	4.83	3.30	4.89	7.75
CaO .....	0.06	8.68	9.84	8.09	9.96
Na <sub>2</sub> O .....	2.21	3.31	2.84	3.23	2.50
K <sub>2</sub> O .....	0.80	1.33	0.63	1.70	0.84
H <sub>2</sub> O I .....	2.45	3.22	1.69	1.83	0.66
H <sub>2</sub> O - .....	0.87	—	0.43	—	—
TiO <sub>2</sub> .....	1.35	0.95	1.72	0.68	1.42
P <sub>2</sub> O <sub>5</sub> .....	abs.	0.35	abs.	0.20	0.44
MnO .....	0.10	—	0.21	0.46	0.17
CO <sub>2</sub> .....	2.81	2.90	abs.	—	—
Other Const. ....	—	—	0.33	—	—
	99.58	99.57	100.56	100.00	100.00

- I. Altered Dolerite. Dyke on River Lett, between Lett and Glenroy Bridges. Anal. G. A. Joplin.  
 II. Melaphyre. Sommerberg, Thüringerwald. Anal. G. F. Steffen. In W.T., p. 876, No. 110.  
 III. Altered Diabase. Tamarack, Minnesota. Anal. A. W. Johnston. In W.T., p. 868, No. 36.  
 IV. Osann's average melaphyre (Daly, 1914, p. 27).  
 V. Osann's average dolerite (Daly, 1914, p. 27).

#### *Name of the Rock.*

It is evident from the foregoing petrography and from the chemical analysis that the rocks have suffered much deuteric alteration, and this must be taken into consideration in naming the rock.

The chemical and mineral composition and the mode of occurrence suggest some type of dolerite.

As quartz occurs either as xenocrysts or as a released mineral, its presence cannot be taken into account; moreover, there is nothing else to suggest that the rocks may have been quartz-dolerites.

Many of the less altered types, however, contain small quantities of brown hornblende, and the dolerites may thus be called hornblende-dolerites or proterobases. The proterobase is regarded as a member of the spillite suite (Dewey and Flett, 1911) and, like all members of this suite, they are characteristically albitized and chloritized. These alteration products are quite common among normal basic rocks, and even if there be a spillite suite, there seems no reason why the Hartley dykes should not be regarded simply as deuterically altered dolerites, which sometimes contain a little primary hornblende.

*Similar Dykes elsewhere in New South Wales.*

In the three granite areas examined by the writer, namely, Hartley, Sodwalls and Gumble, altered dolerite dykes have been found associated with granite.

At Sodwalls one such dyke cuts the granite near Wilson's Quarry on the Old Railway Line just north-east of Sodwalls station. In the hand specimen and under the microscope this rock is identical with one from Hartley. Other similar dykes occur in the Sodwalls granite, but they have not been observed among the sedimentary rocks outside the contact aureole.

At Gumble only one basic dyke is recorded. This may be observed cutting acid dykes about 800 yards from the granite contact in Portion 21, Parish of Gumble. Petrographically this rock also compares closely with Hartley and Sodwalls types.

L. A. Cotton (1915) has described two large dolerite dykes at Copeton in the New England. These were investigated for an economic reason, as two diamonds in a doleritic matrix had been found in the area. The present writer has had the privilege of examining Professor Cotton's slides, and has found that the Copeton and Hartley rocks compare very closely. The Copeton dolerites contain a little quartz and, though some of it appears to have been derived from the granite, as at Hartley, a part of it may be primary and the rocks may have affinities with the quartz-dolerites. At Copeton the dykes invade the acid granites of the New England Complex and are partly overlain by Tertiary basalts with which they have no petrological connection.

*Geological Age of the Dykes.*

The geological age of the Hartley dykes is uncertain. They are post-granite and pre-Kamilaroi, but that is all that can be deduced from the field evidence, although the fact that they are never found outside the contact aureole may have some significance. At Hartley, however, the Kamilaroi overlies the Upper Devonian Series on the north and east, and it is impossible to examine the older formation at any great distance from the contact-zone. Nevertheless, similar dykes at Sodwalls, at Gumble, and at Copeton, appear to be restricted to an area close to the granite.

This slender evidence suggests that the dyke swarm belongs to the plutonic complex and it is pertinent to examine the chemical evidence.

It has been pointed out that the analysed rock is characteristically altered and that, with its rather low magnesia, it compares with other altered doleritic rocks. Magnesia, therefore, appears to be lost during the process of alteration, and local concentrations of chloritized dolerite (see p. 265) suggest that MgO is subtracted from one part of the dyke and accumulated in another.

The Hartley dykes show three types of alteration—albitization, chloritization and alteration to carbonates, and the rock chosen for analysis was one in which all three types were present in about equal amount. To some extent, therefore, the low magnesia must be regarded as an inherent property of the magma.

In column II below, the dolerite has been re-calculated to 100% omitting carbon dioxide and water, both of which play an important part in the deuteric processes. Column III represents the composition of a hypothetical rock interpolated from the variation-diagram of the Hartley plutonic series (Joplin, 1931, 1933). The high  $\text{Al}_2\text{O}_3$  and  $\text{MgO} < \text{FeO}$  is noteworthy in the two analyses, and their close correspondence is suggestive, but not entirely convincing. Nevertheless, in the absence of other evidence as to the age of the basaltic dykes, it seems reasonable to consider them as a late phase of the plutonic intrusion, which would correspond to the normal lamprophyric end-phase.

	I.	II.	III.
$\text{SiO}_2$ .. .. .	46.84	50.12	50.10
$\text{Al}_2\text{O}_3$ .. .. .	18.50	19.80	19.80
$\text{Fe}_2\text{O}_3$ .. .. .	5.75	6.15	5.20
$\text{FeO}$ .. .. .	4.80	5.22	5.70
$\text{MgO}$ .. .. .	3.89	4.16	4.40
$\text{CaO}$ .. .. .	9.06	9.00	9.80
$\text{Na}_2\text{O}$ .. .. .	2.21	2.36	2.15
$\text{K}_2\text{O}$ .. .. .	0.80	0.80	0.80
$\text{H}_2\text{O}^+$ .. .. .	2.45	—	—
$\text{H}_2\text{O}^-$ .. .. .	0.87	—	—
$\text{TiO}_2$ .. .. .	1.35	1.45	0.80
$\text{P}_2\text{O}_5$ .. .. .	abs.	abs.	0.35
$\text{MnO}$ .. .. .	0.10	0.10	0.15
$\text{CO}_2$ .. .. .	2.81	—	—
	99.58	100.00	99.35

I. Altered Dolerite. Dyke on River Lett between Lett and Glenroy Bridges, Hartley. Anal. G. A. Joplin.

II. Column I re-calculated to 100% omitting carbon dioxide and water.

III. Hypothetical rock interpolated from variation-diagram of the Hartley plutonic series (Joplin, 1931).

#### *The Possibility of a Basaltic End-phase.*

The grain-size of the dolerites and their method of emplacement indicate that the granite was solid before the invasion of the dykes. The assimilation of some of the granitic material (Culey and Joplin, 1937), however, suggests that the plutonic rock may have been still hot when it was engulfed by the basic magma.

Bowen (1915, 1928) has pointed out that the sinking and resorption of biotite and hornblende crystals during the granite stage of differentiation of a basaltic magma will cause an enrichment of alkalis in the melt. The resorption of hornblende crystals in the "hot liquid" will give rise to a series of more basic minerals such as olivine, augite and anorthite, and these will be precipitated, since they are not in equilibrium with the liquid phase. In this way it is possible to account for the late formation of basic lamprophyres in plutonic complexes.



It seems not unreasonable to suppose that a doleritic rock may be derived from these basic constituents, and instead of the parallel development of an independent alkaline rock, it is possible that the concentrated alkalis and volatiles will react with the dolerite, causing albitization and other deuteric phenomena.

Furthermore, Bowen (1928, p. 270) explains that the "hot liquid" necessary for the resorption of hornblende must be of the nature of a basaltic liquid, and if such be available at this late stage in the differentiation process, it is not unlikely that it could be injected without differentiation as basalt or dolerite dykes.

#### *Summary and Conclusion.*

A series of altered dolerite or proterobase dykes are described. These invade granite and the metamorphic rocks of its contact aureole, and it is suggested that the dykes may be an end-phase of the plutonic intrusion. Chemical evidence is adduced to support this suggestion, and the possible type of differentiation is briefly discussed.

In conclusion, it is suggested that basaltic dyke-rocks may take the place of, or occur with, lamprophyres as an end-phase in a plutonic series. In view of the fact that altered dolerite dykes have been found associated with granites in the only three granitic masses examined by the writer, it seems possible that careful search may reveal them in other areas. Granites and associated dyke-rocks are described from numerous mining regions, but in many cases the reports do not concern themselves with petrological detail and most of the basic dykes are said to be lamprophyres. It seems not unlikely that, if more detailed petrographic work be carried out, some of the "lamprophyre" dykes may prove to be of a basaltic nature.

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# THE ECOLOGY OF THE UPPER WILLIAMS RIVER AND BARRINGTON TOPS DISTRICTS. I.

## INTRODUCTION.

By LILLIAN FRASER,\* D.Sc., and JOYCE W. VICKERY,† M.Sc.

(Plate xiv, two maps and ten Text-figures.)

[Read 27th October, 1937.]

The coastal districts of New South Wales are largely occupied by a forest formation dominated by species of the genus *Eucalyptus*. Two additional formations are present, the sub-tropical and the sub-antarctic rain-forests. These occur east of the Great Dividing Range in sheltered areas of good soil and a high rainfall. Both these formations are usually to be found in isolated areas in river and mountain valleys or on soil derived from basalt. The sub-tropical rain-forest is found chiefly in the northerly parts of the State, and the sub-antarctic rain-forest at high elevations in the centre and north, and in Victoria.

Each isolated area of rain-forest is relatively homogeneous and usually has a characteristic composition, differing slightly in this from neighbouring areas. Those furthest south are depauperated and mixed with Eucalypt forest components. As one progresses north the forests increase in richness of species, and in complexity and density.

Parts of the Eucalypt forest formation have been described in detail by Petrie (1925), Patton (1933), Petrie, Jarrett and Patton (1929), and Davis (1936).

The only ecological work on New South Wales rain-forests is that of Brough, McLuckie and Petrie (1924), who examined an area of impure sub-tropical rain-forest on basaltic soil at Mount Wilson. A comprehensive account of the distribution of rain-forests in eastern Australia and the soil on which they occur is given by Francis (1929). Apart from these nothing has been published on the New South Wales rain-forests except lists of species found in localized areas (Maiden, 1894, 1895, 1898; Chisholm, 1934, 1937).

Petrie, Jarrett and Patton (1929) described the impure sub-antarctic rain-forest of Victoria, and recently Tommerup (1934) described the sub-tropical rain-forest and Eucalypt forest formations in southern Queensland. Herbert (1935) has defined the area in Australia which should be suitable for the development of rain-forest, basing his calculations on temperature and effectiveness of precipitation. According to Herbert most of the coastal rain-forest of New South Wales occurs in the area of mild mesothermal climate, and the conditions of precipitation effectiveness favourable to the development of rain-forest are shown to be discontinuous.

\* Most of this work was carried out while the writer held a Linnean Macleay Fellowship in Botany.

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Very little planned ecological work has been attempted on tropical rain-forests. The most important in recent years is that of Davis and Richards (1933-4) and Richards (1936) on the rain-forests of British Guiana and North Borneo. Earlier investigators have paid special attention to the climatic features of the environment, and to the reaction of the individual species to these, or to the morphology of the component species, or to the general description of plant structures.

The reasons for the lack of intensive work on rain-forests are the inaccessibility of most areas, their complexity, and the difficulty of identification of the component species. The New South Wales rain-forests are, on the whole, accessible and their component species are moderately well known.

In this series of papers a description is given of an area in the Williams and Allyn River valleys (latitude 32° S., longitude 151° 5' E. approx.) in which Eucalypt forests, and sub-tropical and sub-antarctic rain-forests occur. The structure and composition of these forests and the relationships of the rain-forests to the surrounding Eucalypt forest formation are discussed. Regeneration within the forest and along the margins is also described. For comparison brief accounts are given of rain-forests developed in the valleys of associated river-systems.

Except for the Barrington Tops Plateau, the area studied forms part of the Chichester State Forest Reserve. This reserve includes the upper valleys of the Paterson, Allyn, Williams, Chichester and Wangat Rivers. Part of its southern boundary is shown in Map 1. Outside this boundary the country has been extensively cleared for grazing, but inside it is relatively untouched except for some areas in the lower sub-tropical rain-forest and *Eucalyptus saligna* forest where some timber has been cut. The northern limit of the Forest Reserve is the southern escarpment of the Barrington Tops Plateau.

A small amount of grazing by cattle and horses during the summer is carried on on the Barrington Tops Plateau, but grazing is never heavy and does not seem to have caused any important change in the flora.

The Williams River rain-forest area has been found especially interesting for study because it shows the following features:

(i). The contiguity of two different rain-forest formations and their interactions with each other and with the Eucalypt forest formation.

(ii). It is further inland than any other important area of rain-forest in New South Wales, and is separated from the coastal rain-forests by a zone of low rainfall. With the exception of the Gosford and Illawarra sub-tropical rain-forests it is also the most southerly development of this formation of any considerable size. It is, therefore, in a position to yield interesting data relative to distribution and migration of rain-forest species from the north and east.

(iii). There is relatively little variation in rainfall and soil fertility within the area occupied by the rain-forests.

(iv.) Timber cutting has not yet been so severe as to destroy large tracts of the original flora. Before settlement, the Williams River rain-forest was fairly well stocked with good timber of large size. The most important economic species were: red cedar (*Cedrela australis*), rosewood (*Dysoxylum Fraserianum*), white beech (*Gmelina Leichhardtii*), and brown beech (*Litsea reticulata*). Most such valuable timber has been removed from the accessible parts, together with some sassafras (*Doryphora sassafras*), and blue gum (*Eucalyptus saligna*). The more inaccessible parts of the forest towards the head-waters of the river are, however, as yet relatively untouched.

## FACTORS OF THE ENVIRONMENT.

*Physiography.*

## (a) General.

The main dividing range, which for the most part is parallel with the coast-line, has been cut back considerably by the western tributaries of the upper Hunter River, so that here it is further west than elsewhere in New South Wales. This part of the range is also much lower than the areas to the north and south, and thus forms a gap 1,800 feet above sea-level which has been called the Cassilis Geocol. At the point where the main range swings west around the Hunter valley, a branch, the Mount Royal Range, diverges from it, trending south by south-east. This, increasing from about 2,000 feet to a maximum of about 5,000 feet, culminates in a plateau region, the Barrington Tops Plateau (Map 2). To the south the plateau has a decided margin or edge in the form of an escarpment (Plate xiv, fig. 2), and its boundary is also well defined to the west (Plate xiv, fig. 3), but in other directions the boundaries are less sharp.

The western part of the Mt. Royal Range and the Barrington Tops separate the upper Hunter River and its tributaries from the southern tributaries of the Manning River (Map 2). From the southern escarpment of the Barrington Tops Plateau there runs a very striking series of parallel and relatively simple ridges which separate the Paterson, Allyn, Williams and Chichester Rivers, tributaries of the lower Hunter River (Plate xiv, figs. 1 and 2). To the east, ranges of decreasing size separate the head-waters of the Karuah and Gloucester Rivers.

The topography of the Barrington Tops Plateau is of a mature nature, its height above sea-level being about 4,500-5,000 feet. It extends about 6-10 miles in an east-west direction by about 15 miles in a north-south direction. It is part of a late Tertiary peneplain which once extended over the whole of eastern Australia, which has been raised and almost completely eroded. This small residual area is, however, partly undissected and must show in places much the same topography as it did before the uplift. On the plateau towards its southern extremity the landscape is characterized by undulating country with gently rounded hills rising to a height of 200 feet above the general level, and considerable swamps which occupy the low ground between (Plate xiv, fig. 7). These swamps form the head-waters of the Barrington River, which flows in a general easterly direction. After leaving the plateau the Barrington River plunges into a deep, narrow chasm which is gradually cutting back and draining the swamps. To the south the plateau ends abruptly in the escarpment overlooking the heads of the Williams, Allyn and Paterson Rivers (Plate xiv, fig. 4). The northern part of the plateau is drained by the Pigna, Barney, Tomalla, Gummi (Upper Manning), Dillgry and Morpey Rivers, whose courses show a sequence similar to that of the Barrington River. The only streams of any size which drain the plateau to the west are the tributaries on the eastern bank of the upper Hunter River, the Rouchel, Moonan and Stewart's Brooks. In their upper parts these are entrenched to a considerable extent.

## (b). Detailed description of the area studied.

The valleys of the Paterson, Allyn, Williams and Chichester Rivers, which arise from the southern escarpment of the Barrington Tops Plateau, are separated by ridges which are at first flat topped and fairly wide (Plate xiv, fig. 2). These diminish in height from 5,000 feet to 1,600 feet at Salisbury in the Williams River valley and Eccleston in the Allyn River valley, becoming progressively narrower as the valley floors increase in width and become flatter (Plate xiv, fig. 4). The

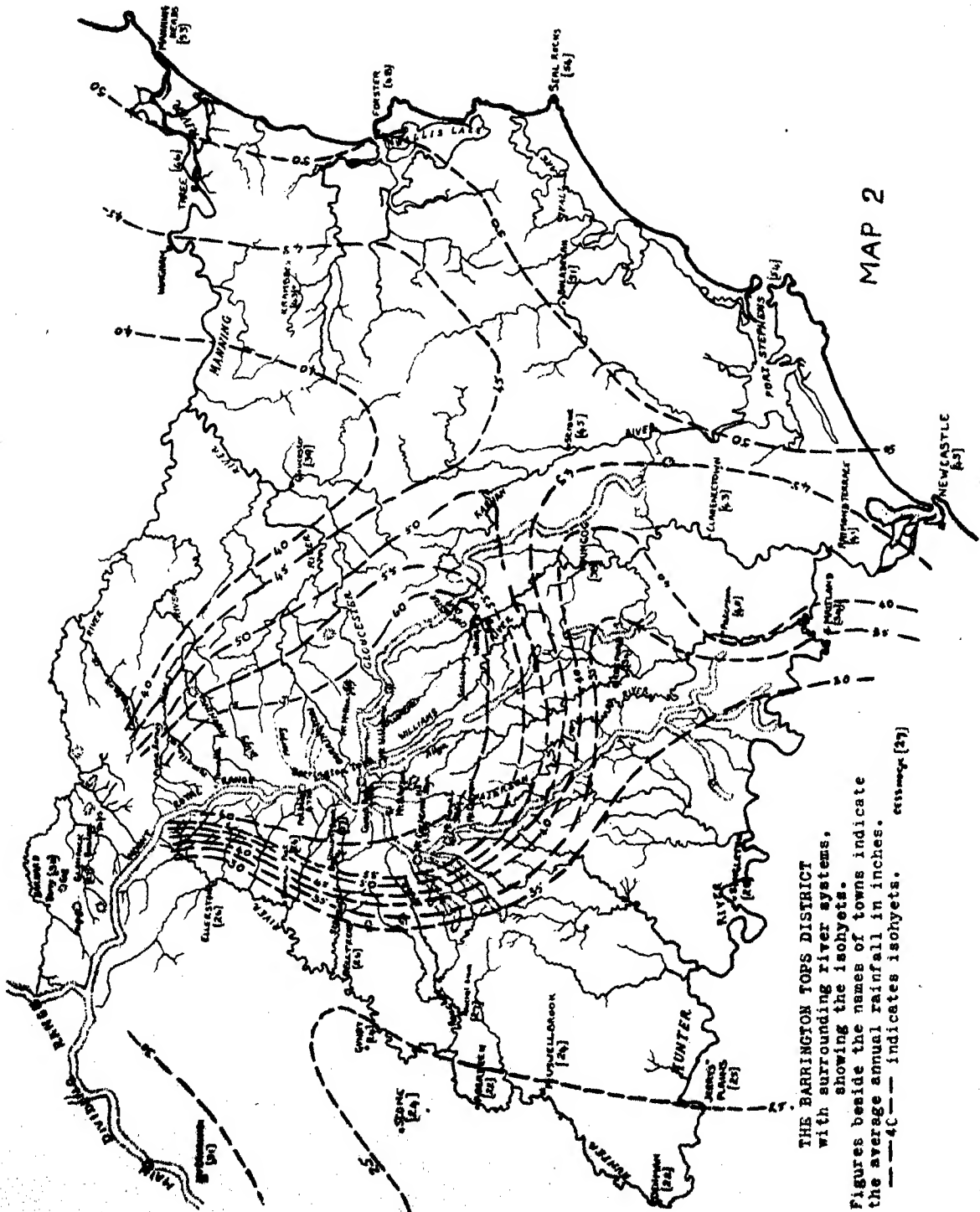
MAP 1

The  
UPPER WILLIAMS  
and  
ALLYN RIVER VALLEYS

showing the dissected  
nature of the dividing  
ridges.

—, approximate boundary  
of basalt rock  
(after G.D. Osborne)  
- - - - - boundary of State  
Forest.





ivers have few affluents of any size, but the dividing ridges are dissected by numerous small creeks and therefore have a complex system of spurs (Map 1). The lateral slopes of the ridges are very steep,  $15^{\circ}$ - $45^{\circ}$  or more, being steepest near the plateau (Plate xiv, figs. 1 and 2). In the upper parts of the Allyn and Williams valleys occasional vertical rock faces occur. These are not numerous, as the nature of the rock causes it to weather into steep slopes. The lower parts of the main spurs and the lower spurs are less steep, and the small creeks which drain them are entrenched to a depth of 100-200 feet, so that their beds and sides are more sheltered than the crests of the spurs. The upper courses of the creeks which drain the flat parts of the ranges near the Barrington Tops Plateau have a tendency to be swampy. On leaving the tops of the ridges they become very steep and the creeks are deeply entrenched.

The valley of the Williams River is  $2\frac{1}{2}$  miles wide from ridge to ridge at the southern limit of the rain-forest (X in Map 1), and narrows gradually towards its source. It is enclosed by ranges averaging about 700-1,000 feet higher than the river bed, trending south-south-east and north-north-west. The valley floor and lower slopes are therefore shaded from the sun and sheltered from the winds to a greater degree than the upper slopes and crests of the ridges. Towards the head-waters of the river the country is very rough and its detailed topography is unmapped. The whole course of the river is marked by cataracts and falls as far south as Salisbury, so that the upper part is not much more entrenched in the mountains near its source than it is at 1,000 feet.

The Allyn-Williams divide (the Williams Range) is uniformly high and protects the Williams valley from westerly winds. The Allyn River valley is rather wider than the Williams (about 3 miles) and the westerly mountain range is less uniformly high than the Williams Range, so that the lower part of the valley is less sheltered than that of the Williams at a corresponding point south.

The head-waters of the Allyn River are entrenched about 3,000 feet below the southern escarpment of the Barrington Tops Plateau; this upper part of the valley is therefore as shaded and sheltered as any part of the Williams valley (Plate xiv, figs. 1 and 4).

The Chichester-Williams divide (the Chichester Range) is more broken than the Williams Range, and the Chichester valley is therefore slightly less sheltered and shaded than the Williams and upper Allyn valleys. The valley is wider than that of the Williams, the slopes less steep, and the actual floor of the valley less flat. The head-waters are very sheltered.

The different degrees of shelter met with in the three valleys have a marked influence on the vegetation.

#### *Geology.*

The writers are indebted to Dr. G. D. Osborne, of the Department of Geology, University of Sydney, for the following information.

A large area of the Barrington Tops Plateau is occupied by quartz-monzonite and associated plutonic types in the form of a batholith. The remainder is composed of flows of basalt and sheets and sills of dolerite. This basalt also forms the tops of the ranges diverging from the plateau. The base of the basalt flows varies in height, but in the vicinity of the Williams River stands at about 1,800-2,000 feet above sea-level (Map 1).

Below the basalt, occupying the valley floors and sides of the ridges, are Carboniferous sediments, chiefly impure limestone and mudstone.

Dr. Osborne concludes that after the Carboniferous sediments were laid down they were subjected to folding, and then eroded in the late Tertiary to a peneplain having as its surface Carboniferous sediments and some dioritic and monzonitic masses intrusive into the Carboniferous rocks and standing above them. Tertiary flows of basalt were poured on this, and later plugs and sills broke across the flows. The plutonic rocks outcropping on the plateau are evidently part of an old residual around which the flows of basalt were poured out.

The great difference in the elevation of the plateau and the lowlands to the south has been attributed by some geologists to step faulting, throwing to the south, but no evidence has been found by Dr. Osborne in support of this view. He considers that the condition is due mainly to erosion.

#### Soil.

The Carboniferous sediments outcropping in the Williams and Allyn River valleys and ridges weather to form a light-coloured clay. Along the valley floor the soil may be of considerable depth and greyish to blackish-brown in colour with humus and material derived from the basalt rocks on the ridge tops. The usual soil of the valley sides and spurs is a yellowish clay which appears to be of considerable depth, while rock outcrops are rare.

The basalt capping the ridges weathers to a chocolate-brown or dark grey, loamy clay. On the flat ridge tops and on the plateau, rock outcrops are very rare and the soil appears to be deep. On the steep upper sides of the ridges approaching the plateau, outcrops of partially decomposed basalt and occasional rock faces can be seen. The soil is deep in pockets, and does not appear to be washed off to any great extent because of the continuous vegetation cover.

On the dioritic part of the plateau occasional rounded boulders occur as in typical granite country; for the most part the soil is a deep, slightly sandy loam.

No detailed study of the soils derived from the various rock formations has been made. From field observations it appeared improbable that the nature of the soil or parent rock was a limiting or deciding factor in the distribution of the plant formations or the species within the area, except perhaps in rare instances. On the other hand, certain aspects of the soil, such as the humus content, were very obviously governed by the plant cover. It was therefore considered necessary at this stage to make only a few comparative tests on a number of representative samples from different localities and from the different plant formations, as illustrations of the edaphic conditions of the area. The soil samples were all taken from about 5 cm. below the surface of the soil.

Table 1 summarizes the results of analyses of the humus content, water-retaining capacity, pH, and some mechanical features of the soils tested. The soil textures were determined according to the method of Hardy (1928). The humus content was estimated by the hydrogen-peroxide method (Prescott and Piper, 1928). The pH was determined by the quinhydrone electrode method. The water-retaining capacity was obtained by estimating the percentage loss of weight from a saturated soil sample dried at 25° C.

No. 1 soil sample is a chocolate-coloured fine silt taken from a typical part of the valley floor covered by sub-tropical rain-forest.—No. 2 is a greyish-brown fine silt taken close to a small creek, and covered by sub-tropical rain-forest.—No. 3 is a yellowish fine silt taken from the lower slopes of a spur covered by sub-tropical rain-forest.—No. 4 is a greyish-brown fine silt taken near a creek, supporting *Tristania conferta* and some rain-forest trees.—No. 5 is a greyish-brown heavy loam from an area occupied by the margin of the sub-tropical rain-forest.—



No. 6 is a greyish-brown fine silt taken from a ridge near No. 7, but from an advancing margin of the sub-tropical rain-forest.—No. 7 is a yellowish-brown heavy loam taken from the top of a ridge, supporting Eucalypt forest.—No. 8 is a greyish-brown fine silt taken high up on the slopes of the Williams-Allyn ridge and supporting a Eucalypt forest association.—No. 9 is a dark chocolate clay from the top of an exposed ridge, about 3,500 feet altitude, supporting Eucalypt forest.—No. 10 is a dark chocolate-coloured clay supporting sub-antarctic rain-forest, at an altitude of about 4,000 feet.

No. 1 is river alluvium, No. 2 is derived from limestone, Nos. 3, 4, 5, 6, 7, 8 from mudstone, and Nos. 9 and 10 from basalt.

The soils vary in texture from a heavy loam to clay, and have a fairly high water-retaining capacity. The marked difference between the figures for the loss on ignition and the humus content of most of the soils is accounted for by the presence of a considerable amount of finely-divided organic matter which cannot be separated from the soil, but which is as yet only partially decomposed. In some instances the soils were of such a peaty nature that on ignition they burned with a pronounced flame, e.g., sample No. 10.

TABLE 1.

Soil Number.	Soil Type.	Sand. %.	Water-retaining Capacity. %.	Loss at 100° C. %.	Loss on Ignition. %.	Humus Content. %.	pH.
1	Fine silt .. ..	0	44	4.1	15.8	11.2	5.75
2	Fluc silt .. ..	7.5	34	2.5	10.7	6.7	4.45
3	Fine silt .. ..	5.5	38	5.2	17.1	7.8	5.3
4	Fine silt .. ..	13.0	35	2.5	10.2	6.7	4.9
5	Heavy loam .. ..	8.8	26	2.9	8.3	4.2	5.4
6	Fine silt .. ..	0.2	42	4.5	18.6	10.9	4.9
7	Heavy loam .. ..	12.7	30	3.0	9.8	5.2	5.0
8	Fine silt .. ..	11.4	35	4.7	11.8	7.0	5.2
9	Clay .. ..	0.7	39	12.1	24.0	10.9	5.65
10	Clay .. ..	0	45	14.2	44.9	20.5	4.5

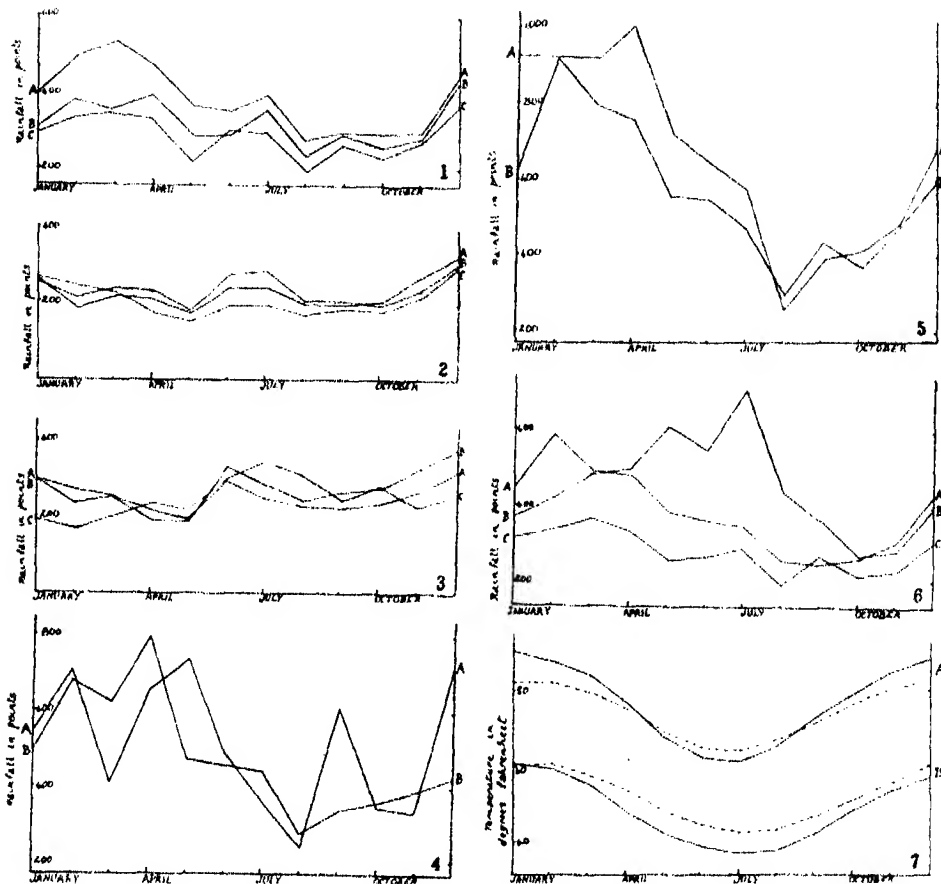
The surface of the soil in the sub-tropical rain-forest is covered by a layer of partly-decayed leaves and twigs to a depth of 1-3 cm. or more, depending on the position. An even greater amount is present in the sub-antarctic rain-forest, where, owing to the lower temperature, decay is probably slower. A considerable accumulation of dry and partly-decayed leaves and twigs is also present on the surface of the ground in the Eucalypt forest.

The soil of the rain-forests is continuously damp, the more so at the higher levels. The soil of the Eucalypt forests is frequently dry. The upper Eucalypt forests are moister than the lower.

#### *Climate.*

##### (a). Rainfall and Winds.

No rainfall data are available for the Barrington Tops Plateau, or for the upper parts of the river valleys draining it. The stations nearest to the area under investigation at which rain records have been taken are Wangat (6,017 points p.a., average for 6 years only) to the south-east of the plateau on the upper Chichester River, and Stewart's Brook (5,704 points p.a.) to the west.



Text-figures 1-6 show the average monthly rainfall recorded for stations in the vicinity of the Barrington Tops.

Text-fig. 1.—Stations east and south-east of the plateau in the dry belt. A, Stroud (average of 46 years); B, Dungog (average of 37 years); C, Gresford (average of 38 years).

Text-fig. 2.—Stations in the Upper Hunter Valley west of the plateau. A, Moonan Flat; B, Rouchel Brook; C, Scone (average of 59 years).

Text-fig. 3.—Stations north-west of the plateau, near the Mount Royal Range or Main Dividing Range. A, Murrurundi (average of 64 years); B, Nundle; C, Barry.

Text-fig. 4.—Stations nearest to the plateau. A, Wangat (average of 8 years); B, Stewart's Brook.

Text-fig. 5.—Stations on highland areas to the north of the plateau. A, Dorrigo (average of 19 years); B, Comboyne (average of 30 years).

Text-fig. 6.—Stations on or near the coast, east of the plateau. A, Taree (average of 52 years); B, Port Stephens (average of 44 years); C, Maitland (average of 68 years).

Text-fig. 7.—Average mean maximum (A) and average mean minimum (B) temperatures for stations nearest to the Barrington Tops Plateau at which records are kept. ——— Scone (height above sea-level, 682 feet); - - - Taree (height above sea-level, 31 feet).

The rainfall is chiefly due to the north-east monsoons which operate during the late summer and autumn. A certain amount of rain is also received from southerly rain-bearing winds which blow chiefly during the winter and, approaching the plateau along the parallel valleys of the Allyn, Williams and other rivers, precipitate their moisture on the southern margin of the plateau and dividing ranges. Though no data are available, it seems probable that the greatest amount of rain is received by the south-eastern and north-eastern margins of the plateau at about 4,500-5,000 feet.

An attempt has been made to plot from records available the distribution of rainfall in the districts surrounding the plateau (Map 2). It can be seen that the annual rainfall decreases from the coast inland, rising again as the highlands are approached, so that there is a zone including the lower Williams and Paterson River valleys which is comparatively dry. Wangat, with an altitude of about 1,000 feet, receives the highest rainfall recorded, viz., 6,017 points. The rainfall is probably high along the whole of the Mt. Royal Range, but owing to the direction of the rain-bearing winds the greatest rainfall must be received by the south-easterly and southerly margins of the plateau. By analogy with the similarly-placed highland masses of the Comboyne and Dorriggo plateaus to the north, and from the appearance of the vegetation, it seems likely that the plateau itself must receive considerably more than this, probably more than 8,000 points p.a.

The amount of rain received diminishes very rapidly to the west of the plateau region. In the region of the Cassilis Geocol the Dividing Range does not appear to be an effective barrier to rain-bearing winds and consequently this region receives a relatively small amount of rain. The dryness of this area is, no doubt, in part due to the sheltering action of the Barrington Tops Plateau.

The distribution of rainfall throughout the year in the area surrounding the plateau is shown in Text-figures 1-6. It can be seen that a well-defined dry season is not experienced in any of the localities; a fairly even amount of rain is received throughout the year. There is a slight tendency for a maximum in the autumn in the Dungog, Clarencetown and coastal districts (Text-figs. 1 and 6), but this is not shown in the upper Hunter River district (Text-figs. 2 and 3). Stewart's Brook appears to receive its greatest rainfall in the late summer and autumn, but at Wangat no well-defined maximum occurs (Text-fig. 4). This is not in agreement with the records from Dorriggo and Comboyne (Text-fig. 5), which show a well-marked maximum in the autumn, and a minimum in the late winter and early spring. It is possible that a similar distribution of rainfall may occur on the Barrington Tops Plateau itself.

Throughout the summer and autumn mists are common at 4,000 feet altitude and above. These keep the upper forest permanently very wet, and encourage the growth of epiphytic lichens and mosses. The eastern parts of the plateau (2,500 feet and above) are within the sphere of influence of the sea breeze, which often causes the precipitation of light showers in the very early morning.

The only desiccating wind in the region under discussion is the westerly, which blows chiefly in the autumn, winter and early spring.

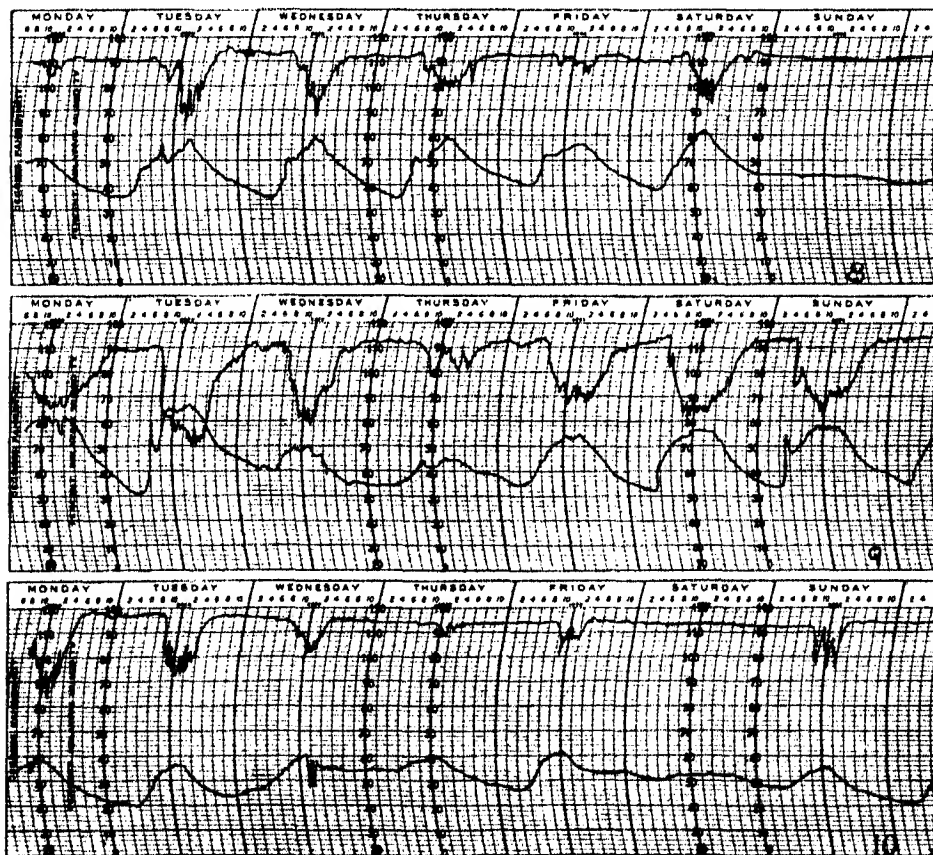
#### (b). Temperature and Humidity.

No continuous temperature data are available for the area investigated. Text-figure 7 shows the mean maximum and minimum temperatures for Scone and Taree, the nearest places to the area for which records are available.

Within the sub-tropical rain-forest the temperature does not vary as much as it does in the Eucalypt forest; high temperatures are uncommon. This is due to the insulating effect of the very dense canopy. The thickness of the canopy means that there is practically no wind in the rain-forest, and hence the evaporation rate is very low and the humidity is high. This is especially noticeable as the small drop of temperature consequent on the setting of the sun behind the ridges results in a heavy dew within the rain-forest causing the trunks of the *Eucalyptus saligna* trees to become wet to a height of 30-40 feet.

Since the Eucalypt forest is relatively open the evaporation rate is much higher than in the rain-forest, and the humidity is lower.

Some isolated observations on temperature and humidity have been made in the lower rain-forest and adjacent cleared areas in the Williams River valley.



Text-figures 8-10 are Thermohygrograph records. The upper line indicates humidity, the lower line temperature.

Text-fig. 8.—Record in the lower sub-tropical rain-forest, 22nd to 28th January, 1935.

Text-fig. 9.—Record in a clearing near the sub-tropical rain-forest, 10th to 17th January, 1935.

Text-fig. 10.—Record in the lower sub-tropical rain-forest, June, 1935.

Some of these are shown in Text-figures 8-10, and illustrate the effect on the humidity of the rain-forest canopy. These were recorded by an Edney Thermohygraph during summer and winter months. It was not possible to have records taken simultaneously in the rain-forest and in the cleared area, but the records shown in Text-figures 8 and 9 represent consecutive weeks of similar weather in summer. It can be seen that the daily variations are much more extreme in the cleared area. For comparison, Text-figure 10 shows a typical record for humidity and temperature for a week in June (winter) in the rain forest. It is evident from the records taken that the humidity is more uniformly high in the winter than in the summer.

No records were taken of variation of humidity from ground level to the top of the canopy. It has been found elsewhere (e.g., Davis and Richards, 1933) that in rain-forests the humidity falls off rapidly from the ground to the level of the canopy.

Frosts occur occasionally during the winter at ground level in cleared areas below the rain-forest, at about 1,000 feet altitude, but the forest cover prevents their formation in uncleared areas below about 2,000 feet. Above this altitude frost forms at ground level within the forest, the actual height at which it occurs being to some extent dependent on the degree of shelter from the west and the type of cover.

During the winter months, June to August, some falls of snow are customary on the plateau and ridges down to 4,000 feet, rarely to 3,000 feet on exposed places. The snow does not lie long on the ground, especially at the lower levels. On the plateau it is exceptional for it to remain for more than a week. It does not lie as long on swamp as on forest and grassland country.

The climate of the plateau approximates to the microthermic type similar to that responsible for the beech forests of Western Tasmania.

#### (c). Sunlight.

Crests of the spurs and the upper parts of slopes exposed directly to the west receive maximum sunlight, and high temperatures are probably experienced there; but they also experience maximum evaporation and consequently lowest temperature. The valley floor and sheltered gullies on northerly slopes probably experience least extremes of temperature.

Direct sunlight leaves the upper Williams River valley at about 2.30 p.m. during the winter months, and at about 4.30 p.m. during the summer months, and correspondingly earlier on the sheltered slopes. (In Sydney the sun rises at 6.58 a.m. and sets at 4.54 p.m. on the shortest day, 21st June, and rises at 4.41 a.m. and sets at 7.06 p.m. on the longest day, 21st December.) Some of the entrenched creeks on the northern slopes must receive only a few hours direct sunlight per day.

In the Eucalypt forest a considerable amount of sunlight reaches the ground level, as the canopy is thin. In the rain-forest, especially the sub-tropical rain-forest, only small flecks of sunlight reach the ground and the general lighting is very diffuse.

#### STRUCTURE OF THE PLANT FORMATIONS.

Throughout the area studied the plant cover, of whatever kind, is continuous. Very little exposed rock surface occurs, except on the very steep upper slopes of the range near the plateau, where the basalt outcrops in the form of angular boulders, which support a rich flora of lichens and mosses. Elsewhere the soil is deep and rich and supports a complex flora of trees, shrubs and herbs.

There are, in the area, three distinct types of formation: The Eucalypt forest, the sub-antarctic rain-forest and the sub-tropical rain-forest as defined below.

*Eucalypt forest formation.*—Canopy continuous or nearly so, rather thin; trees 50-180 feet high according to locality; shrubs scanty to numerous, with herbs and grasses forming a continuous ground cover. This formation extends over the whole coast and adjacent highlands of New South Wales, *Eucalyptus* being the dominant genus.

*Sub-tropical rain-forest formation.*—Canopy continuous, very dense, moderately deep; trees very numerous, 60-120 feet high; shrubs and young trees fairly numerous; ground flora mostly ferns with few herbs, scanty except in light breaks; epiphytic ferns and Angiosperms and lianes numerous, giving this forest a characteristic appearance; trees belonging to a large number of different genera.

The same general type of formation is found throughout the moist areas of the tropics and extends to sub-tropical countries. The sub-tropical rain-forest of eastern Australia has closest affinities with that of the Indo-Malayan Islands. Its composition is less rich and dense, however, and it has few actual species and genera in common with it.

As understood in this paper, the term sub-tropical rain-forest is synonymous with the term brush as used in New South Wales, but not in Queensland, and with the terms scrub and jungle as used in Queensland.

*Sub-antarctic rain-forest formation.*—Canopy continuous, fairly dense, very deep; trees 90-150 feet high; one species often dominant; tree-ferns and ferns very numerous in damp places, otherwise the ground flora rather scanty; lianes and epiphytic ferns and Angiosperms very few. It is part of the formation extending into Tasmania, parts of New Zealand and South America. The number of species present is smaller than in the sub-tropical rain-forest.

#### GENERAL DESCRIPTION OF THE VEGETATION OF THE AREA.

The upper sheltered parts of the valleys of the rivers draining the south-east, east, and north-east of the Barrington Tops Plateau are occupied by the sub-tropical rain-forest formation. Its extent in any particular area depends on the degree of shelter from the west, and on the rainfall. In no case in this district does the formation extend below about 1,000 feet altitude, as below this level not only are the valleys wider and more sunny, but also, being further from the plateau, the total rainfall is less. The sub-tropical rain-forest occupies the floors and sheltered sides of the valleys and the beds of creeks which drain the spurs. Towards the lower margin it does not occupy the whole valley floor, but is present only on the banks of the river. In favourable places it extends upwards to a height of 3,000 feet. At this height it gives place gradually to the sub-antarctic rain-forest which extends to 5,000 feet along creeks and sheltered slopes, having its maximum development at 4,000-4,500 feet.

The amount and character of the rain-forest in the different valley systems depends on their aspect and on the rainfall. Its greatest development appears to be in the valleys of the upper Paterson, Allyn and Williams Rivers.

The lower valleys of Stewart's, Moonan and Rouchel Brooks, which are exposed to the west and receive a lower rainfall, do not support a true rain-forest. Their upper courses, which are slightly entrenched in the plateau and are therefore sheltered, appear to support a few patches of sub-antarctic rain-forest.

The upper parts of the Barrington, Manning, Tomalla and Curriecabark Rivers, where they are entrenched in or near the plateau, support both sub-tropical and sub-antarctic rain-forest.

The lower valley of the Manning, into which these streams flow, is wide and relatively open (Plate xiv, fig. 6), but a considerable amount of rain-forest is present as far down as Coneac (but only at a level of about 400 feet above the river bed) on sheltered slopes and in the beds of creeks where the soil is moist (Plate xiv, figs. 5 and 6). Plate xiv, figure 6, shows the development of rain-forest on the north-east-facing slope of the valley and its absence from the west-facing slope). This extends in discontinuous patches to Gloucester, linking up there with the rain-forests of the Kramback region described by Maiden (1895).

The valley of the upper Barnard River, which drains the northern part of the Barrington Tops Plateau and the Mount Royal Range, appears to be much drier and does not support a rain-forest vegetation.

The extent of the rain-forest in the upper Karuah and Gloucester River valleys has not been determined.

The valleys below the rain-forest, the crests and upper slopes of ridges, the plateau region, and upper valleys of the western and north-western rivers except actually on the plateau, are occupied by Eucalypt forest. The character of the Eucalypt forest and nature of the undergrowth alter with increasing altitude. The trees reach their maximum height in the valleys, and are smallest on the Barrington Tops Plateau.

The lower lying ground of the plateau is occupied by extensive swamps, and between the swamps and the Eucalypt forest is a grassland community of varying width, from which trees and large shrubs are absent (Plate xiv, fig. 7). The swamps are gradually being drained by the cutting-back action of the Barrington River, along part of whose course the change of vegetation from swamp to grassland and from grassland to forest can be traced.

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## EXPLANATION OF PLATE XIV.

- 1.—View from the southern escarpment of the Barrington Tops Plateau, showing the diverging ridges; the upper valley of the Allyn River is shown in the foreground, with the Allyn Range and upper Paterson River valley beyond.
  - 2.—The upper Williams Range near the Plateau, showing its flat top, and steep slopes and spurs.
  - 3.—Part of the western edge of the Barrington Tops Plateau, east of Moonan Flat, showing the steep slope from the plateau, and the relatively sparse nature of the vegetation.
  - 4.—The Allyn River valley, with the southern escarpment of the Barrington Tops Plateau in the background.
  - 5.—Sub-tropical rain-forest on a sheltered north-east slope in the Manning River valley near Coneac. The rain-forest can be seen in the gullies, the Eucalypt forest on the spurs.
  - 6.—Valley of the Manning River near Coneac, showing the development of rain-forest on a north-east slope (left-hand side), and of Eucalypt forest on west and south-west slopes (right-hand side).
  - 7.—Part of the Barrington Tops Plateau, showing the mature topography and presence of swamps. *Eucalyptus pauciflora* trees occur on the left.
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NOTES ON SOME SPECIES OCCURRING IN THE UPPER WILLIAMS RIVER  
AND BARRINGTON TOPS DISTRICTS, WITH DESCRIPTIONS OF TWO NEW  
SPECIES AND TWO NEW VARIETIES.

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(Two Text-figures.)

[Read 27th October, 1937.]

During an ecological survey of the rain-forests of the upper Williams River valley, and the montane and sub-alpine vegetation of the Barrington Tops districts, a number of species were collected which appeared worthy of record.

As has been described in a previous paper (Fraser and Vickery, 1937), the Barrington Tops is a more or less isolated plateau region rising to an altitude of 5,000 feet. It forms a part of the Mount Royal Ranges, but is surrounded on all sides by considerably lower ground. At the highest points it supports a mixed montane and sub-alpine vegetation, some species of which are identical with or show a close connection with those of the Kosciusko Plateau (7,000 feet) in the south of New South Wales, and in some cases with those of Tasmania. A few species occurring here have apparently not been found anywhere between the Barrington Tops and the Kosciusko Plateaus, which are several hundred miles distant. Many others are not known north of this district. The floristic relationships of the vegetation will be discussed more fully in a subsequent paper on the ecology of the district, but the remarkable distribution of some species made their occurrence here worthy of special comment.

The upper courses of the river valleys draining the Barrington Tops Plateau are partly occupied by sub-tropical rain-forest of Indo-Malayan affinities. This formation is best developed and most complex in structure on the coast of Queensland and northern New South Wales, becoming considerably attenuated in its floristic composition towards its southern limits, at about the Illawarra district of New South Wales. The gradual disappearance of the component species is, no doubt, largely due to temperature. Several species of this formation are not known to extend southwards beyond the Williams River Valley and associated river systems.

As a result of its rather isolated position, the flora of the Barrington Tops Plateau shows a degree of endemism, four species (*Diuris venosa* Rupp, *Prasophyllum Rogerii* Rupp, *Drimys purpurascens* J. Vickery and *Plantago palustris*, n. sp.) being known only from this district. Other species also, e.g., *Gentiana diemensis*, and *Acacia Chumies-Rossiae*, are represented by distinctive forms, which on further study may prove to be worthy of varietal or specific rank.

In this paper two new species and two new varieties are described from the Williams River and Barrington Tops district.

PTERIDOPHYTES.

Family POLYPODIACEAE.

*Blechnum penna-marina* Kuhn. occurs near creeks at an altitude of about 4,600-5,000 feet on the Barrington Tops Plateau. It occurs in Victoria and

Tasmania, and on the Kosciusko Plateau and southern tablelands of New South Wales, but is not recorded north of this area.

Family LYCOPODIACEAE.

*Lycopodium clavatum* var. *fastigiatum* Benth. has been previously recorded only from the Kosciusko Plateau in New South Wales, and extends to Tasmania.

MONOCOTYLEDONS.

Family GRAMINEAE.

*Calamagrostis breviglumis* Hackel is stated, in Moore and Betcher's *Handbook of the Flora of New South Wales*, to be of rare occurrence. It is abundant in the grassland and near the swamps of the Barrington Tops Plateau, and has been observed by the writers to be plentiful on the Comboyne Plateau to the north, and on the Clyde Mountain to the south. The Barrington Tops Plateau is probably near its centre of distribution.

*Hierochloa redolens* R.Br. occurs occasionally beside creeks at an altitude of 4,800 feet. It has been previously known only from the Kosciusko Plateau in New South Wales, and from Victoria at high altitudes, and Tasmania.

*Panicum lachnophyllum* R.Br. has not previously been recorded from New South Wales, but occurs in Queensland. It occurs in the Williams River rain-forest in areas where sufficient light reaches to the ground stratum, but is rather rare. It has also been observed by the writers in the rain-forest at Mount Warning, close to the Queensland border.

*Pollinia nuda* Trin.—This exotic species has not previously been recorded from New South Wales. It extends from South Africa to India, China and Japan, as a shade-loving species. It occurs abundantly in the Williams River district as a river-bank species in the sub-tropical rain-forest, scrambling between the river boulders just above water level, where it receives a moderate amount of sunlight during the middle of the day. It is peculiar to find this exotic species naturalized in such an isolated district. It has not been observed by the writers in any other locality.

Family CYPERACEAE.

*Carex cernua* Boot. var. *lobolepis* F.v.M. has been known only from the New England district at the head of the Macleay and Bellinger Rivers.

*Uncinia riparia* R.Br. occurs in Tasmania, but has previously been recorded only from Yarrangobilly in this State.

Family JUNCACEAE.

*Juncus falcatus* E. Mey. has previously been recorded only from the southern highlands in the vicinity of Kosciusko, and on the Brindabella Ranges. It also occurs in Tasmania. On the Barrington Tops it occurs at an altitude of about 4,800 feet.

Family LILIACEAE.

*Lomandra montana* (R.Br.), nov. comb. Syn.: *Xerotes montana* R.Br. Prod., 1810, p. 262. *Xerotes montana* R.Br. was included by Bentham (*Fl. Aust.*, vii, p. 98) under *X. longifolia* R.Br. It differs from this species, however, in having a shorter and unbranched inflorescence, and fruits which are bright orange coloured and slightly succulent when fresh. It appears to be quite worthy of specific rank. *Lomandra montana* inhabits the rain forests and other shady places in the eastern parts of New South Wales. It is a common constituent of the ground flora in the rain-forest of the Williams River district.

*Lomandra Hystrix* (R.Br.), nov. comb. Syn.: *Xerotes Hystrix* R.Br. Prod., 1810, p. 262. *Xerotes Hystrix* R.Br. was also included by Benthams (*Fl. Aust.*, vii, p. 98) under *X. longifolia* R.Br., from which it differs in the very large, much branched inflorescence. *Lomandra Hystrix* is found from the Hunter River northwards to Queensland in coastal districts. In the Williams River district, and probably also elsewhere, it occurs as a rain-forest margin species, and is not uncommon in sunny areas within the forest, especially in very moist situations.

#### Family IRIDACEAE.

*Libertia pulchella* Spreng.—This district appears to be the northern limit of this species, which is known from the Blue Mountains and southwards to Tasmania.

#### Family ORCHIDACEAE.

In addition to *Diuris venosa* Rupp and *Prasophyllum Rogersii* Rupp, which are known only from the Barrington Tops Plateau, Rupp (1930 and 1937) records the Barrington Tops as the most northern known locality for *Adenochilus Nortonii* Fitzg., *Prasophyllum fimbriatum* R.Br. and *Pterostylis coccinea* Fitzg. *Pterostylis decurva* Rogers, *Pterostylis falcata* Rogers and *Chiloglottis Gunnii* Lindl. have been found only on the Barrington Tops and at Kosciusko in this State (or else in Victoria) and are also common in Tasmania. *Prasophyllum Hopsonii* Rupp is known only from the Allyn River valley immediately south of the Plateau.

#### DICOTYLEDONS.

#### Family FAGACEAE.

*Nothofagus Moorei* Oerst.—It is well known that the Barrington Tops Plateau is the southern limit of the antarctic beech. It is well developed at an altitude of about 4,000-4,500 feet, where it forms an extensive formation in any sheltered locality. It is also well developed on the MacPherson Ranges and at high altitudes in Queensland.

#### Family PROTEACEAE.

##### LOMATIA ARBORESCENS, n. sp. Text-fig. 1.

Arbor parva 4-10 m. alta in locis protectis vel frutex 1-4 m. altus in locis apertis; rami teretes, tenuiter pubescentes vel glabrescentes maturi, summae juvenes ferrugineo-pubescentes; folia alterna, petiolaria; petioli 1-4 cm. longi, saepe puberuli praesertim ad basem; laminae lanceolatae vel ovato-lanceolatae, plerumque longiorae 3-4-plo aliquando 2-plo latis, 6-18 cm.  $\times$  1.5-6 cm. sed aliquando parviores, acutae vel obtusae, contractae gradatim ad petiolos marginibus paulum dentatis, raro sub-laevibus, nunquam lobatis, firmae, sub-coriaceae, saepe aliquanto palidiores raro glaucae subter, paulum lucentes supra, glabratae vel pilis paucis subter praesertim in nervo primo, nervis propinquis reticulatis manifestis supra, nervo primo prominente subter; racemi axillares, aliquando secundi, haud vel vix folia excedentes; pedunculi 8-16 cm. longi, nudi ad basem, simplices vel raro folium parvum ramo secundario in axillaro ferentes, floribus binariis puberulis; pedicelli pubescentes, graciles, 4-8 mm. longi; flores cremei in vivo, nigri in sicco; perianthium circa 7 mm. longum glabratum vel puberulum parte exteriori, glabratum parte interiori, tubiformum, oblique flexum ad apicem, disiunctum 4 segmentis maturitatum; segmenta angustata ad partem mediam, sed dilatata concavaque ad apicem; anthera sub-sessilis in apicis concavis segmentorum, lati, 1-1.5 mm. longi; glandes hypogynae 3, prope partem anteriorem floris, plus vel minus globosae, circa 1 mm. diam., persistentes; ovarium uni-carpellare, polyspermum, super gynophorium circa 4 mm. longum ex quo tempore pollinationis; stylus 4-5 mm.

longus, persistens, ex parte posteriore emergens ante liberationem stigmati; stigma obliqua, dilatata, aliquando conica; folliculus ovato-oblongus, 2.5-3.5 cm.  $\times$  1-1.2 cm. nigro-fuscus, parte inferiore rectus; semina circa 10, planiusculi, 5-6 mm. diam., cum alis tenuibus membranaceis margine crassis 8-24  $\times$  5-7 mm. Williams River: in rain-forest (L. Fraser and J. Vickery, 12/1/1934, Type); at about 3,500 feet (L. Fraser and J. Vickery, 9/1/1934); Barrington Tops: below Carey's Peak (L. Fraser and J. Vickery, 8/1/1936); at 5,100 feet (J. L. Boorman, December, 1915); Nundle (M. H. Simon, July, 1913, No. 21); Comboyne, in rain-forest (L. Fraser and J. Vickery, 21/1/1934); Noorabark Station, New England Tableland (G. R. Brown, Nov., 1909); Coolpi Mountains (J. L. Boorman, October, 1909); Mt. Lindsay, Nandewar Ranges (H. M. R. Rupp, Nov., 1912, No. 28); at 4,500 feet (R. H. Cambage, Nov., 1909, No. 2421); Wilson's Peak at Summit (Macpherson Range) (J. H. Maiden, Dec., 1907).



Text-fig. 1.—*Lomatia arborescens*.  $\times$  0.4.

A small tree 4-10 m. high in sheltered situations, or a shrub 1-4 m. high in more exposed situations; branches terete, sparsely pubescent or almost glabrous at maturity, the young tips rusty pubescent; leaves alternate, petiolate; petioles 1-4 cm. long, often somewhat pubescent, especially at the base; laminae lanceolate to ovate-lanceolate, usually 3-4 times, sometimes only 2 times as long as broad, usually 6-18  $\times$  1.5-6 cm., but sometimes smaller, acute or obtuse, narrowing rather gradually into a petiole, slightly dentate, rarely almost entire, never lobed, firm to almost coriaceous in texture, often rather paler, rarely glaucous underneath, glabrous or with a few hairs on the under surface, especially along the midrib, with closely reticulate veins conspicuous on the rather shiny upper surface, the midrib

protruding on the lower surface; inflorescence an axillary raceme, somewhat one sided, not or scarcely exceeding the length of the leaves; peduncle 8-16 cm. long, naked in the lower part, simple or rarely bearing a small leaf with a secondary branch in its axil, bearing flowers in pairs, sparsely pubescent; pedicels pubescent, rather slender, 4-8 mm. long; flowers cream-coloured in vivo, black when dry; perianth about 7 mm. long, glabrous or sparsely pubescent outside, glabrous within, tubular, curved to one side at the apex, separating into 4 segments at maturity, the segments narrow at the centre but dilated and concave at their tips; anthers subsessile in the concave tips of the perianth segments, broad, 1-1.5 mm. long; hypogynous glands 3, situated towards the anterior side of the flower, more or less globular, about 1 mm. diam., persistent; ovary consisting of one carpel, many seeded, on a gynophore about 4 mm. long at the time of pollination; style 4-5 mm. long, persistent, breaking out through the posterior side of the flower before the stigma is liberated; stigma oblique, dilated, the stigmatic surface somewhat cone-shaped; fruit a follicle, oval-oblong, 2.5-3.5  $\times$  1-1.2 cm., very dark brown, straight along the anterior side, bearing the persistent style and stigma; seeds about 10, rather flat, 5-6 mm. diam. with a fine membranous wing, 8-24  $\times$  5-7 mm. with thickened margins.

This species inhabits the rain-forests, or moist situations in open forests at rather high altitudes in north-eastern New South Wales.

The species of *Lomatia* all show considerable variation, so that it is at times difficult to delimit them, and the situation is further complicated by hybridization which frequently appears to occur when two species are found associated in the field.

*L. arborescens*, however, appears to be specifically distinct from any of those previously described, and no intergrading forms are known. It is perhaps most closely related to *L. longifolia* R.Br., which is also somewhat arborescent in habit, and has short axillary racemes, but is readily distinguished from it by the much broader, lanceolate leaves. It differs from *L. Fraseri* R.Br. in the more glabrous leaves, branches and perianth, the more simple and shorter inflorescence, and the arborescent habit, and from *L. ilicifolia* R.Br. in the arborescent habit, less harsh leaf texture and lateral instead of terminal inflorescence with smaller and more slender flowers.

The leaves are somewhat variable in this species, being large, fairly evenly dentate in the shelter of rain-forests, and smaller, more ovate-lanceolate, sometimes glaucous, and less regularly toothed in more exposed situations.

#### Family SANTALACEAE.

*Erocarpus nana* Hook. f., a very small shrub only a few inches in height, has been previously recorded in New South Wales only from the Kosciusko Plateau. It also occurs in Tasmania. On the Barrington Tops it occurs chiefly in the grass-land association between the swamps and the *Eucalyptus pauciflora* forest at an altitude of about 4,800 feet.

#### Family WINTERACEAE.

*Drimys purpurascens* J. Vickery.—This shrub appears to be endemic to the Barrington Tops Plateau, where it occurs between 4,500 and 5,000 feet. It is common over a small area in the vicinity of Carey's Peak in a *Eucalyptus pauciflora*-*Poa caespitosa* association, but is not very widely distributed over the Plateau.

*Drimys lanceolata* Baill.—This locality is about the northern limit of this species. It occurs chiefly on the southern tablelands of New South Wales and

in Victoria and Tasmania. The form occurring here differs somewhat from the typical *D. lanceolata* in the tendency sometimes to have two carpels in the flower instead of one only, and in the sub-sessile, spatulate leaves. We have no complete flowers, nor mature fruits of this form, but in other respects it appears to be very close to the variable *D. lanceolata*. It occurs here associated with *D. purpurascens*, but is rather more widely distributed over the plateau.

#### Family MONIMIACEAE.

*Atherosperma moschatum* Labill. occurs on the Barrington Tops Plateau at 4,000–5,000 feet along sheltered creeks. This is probably the most northerly locality at which it grows. It occurs chiefly at high altitudes in the Blue Mountains and southern parts of New South Wales, and in Victoria and Tasmania.

#### Family LAURACEAE.

The Williams River rain-forest is about the southernmost limit for *Cryptocarya erythroxylon* Maiden and Betcher, *C. obovata* R.Br., and *Endiandra Muelleri* Meisn. These three species are found in the sub-tropical rain-forests of the northern parts of New South Wales and in Queensland.

#### Family PITTOSPORACEAE.

*Billardiera longiflora* Labill. has previously been recorded only from the Blue Mountains in this State, and from Victoria and Tasmania.

#### Family LEGUMINOSAE.

*Acacia elata* A. Cunn. is at about the northern limit of its range here. It is best developed in the impure sub-tropical rain-forests of the Blue Mountains, and is not common in the Williams River district.

*Acacia Clunies-Rossiae* Maiden was described from Yerranderie, and appears to have been collected previously only from near that district. The specimens from Barrington Tops agree very closely with the type in all respects, except in the fruit, which is considerably broader and slightly shorter, i.e., about  $2.45 \times 0.9-1.1$  cm., with a stipe about 3–4 mm. long. (In the typical *A. Clunies-Rossiae* the fruit is about  $3.7 \times 0.5-0.7$  cm., with a stipe about 3–4 mm. long.)

*Pultenaea fasciculata* Benth. has not been found between the Kosciusko Plateau and the Barrington Tops. It is present also in Victoria at high altitudes and in Tasmania.

#### Family RUTACEAE.

*Pleiococca Wilcoxiana* F.v.M. is at about its southern limit in the sub-tropical rain-forest of the Williams River.

*EVODIA MICROCOCCA* F.v.M. var. *PUBESCENS*, n. var.—Ab typo foliis molliter pubescentibus subter etiam saepe supra, et superficientibus externis petalorum plerumque pubescentibus differt. Bellingen (L. Fraser and J. Vickery, 26/1/1936. Type); Little River (Swain, 3/1910; L. Fraser and J. Vickery, 31/12/1934); Williams River (L. Fraser and J. Vickery, 8/1930); Ourimbah (J. L. Boorman, 1/1908). This variety differs from the type in the softly pubescent undersides and often also the upper surfaces of the leaves, and in the usually pubescent outer surfaces of the petals.

This variety is very easily distinguished in the field, the pubescent character of the leaves giving them a soft, velvety texture. The variety and the type are not infrequently found growing together in some districts. In the Williams River sub-tropical rain-forest this variety only has been found.

Family POLYGALACEAE.

*Comesperma sylvestre* Lindl. is at about its southern limit on the Barrington Tops. It is found chiefly on the northern highlands of New South Wales and in Queensland.

Family SAPINDACEAE.

*Arytera foreolata* Radlk. is at about its southern limit in the sub-tropical rain-forests of the Williams River.

Family VITACEAE.

*Cayratia* sp.—A species of *Cayratia* Juss. (*Cissus* L.) which was stated in a communication from the Royal Botanic Gardens, Kew, during 1936, to be probably an undescribed species near *Cissus* (*Cayratia*) *japonica* (Thunb.) Willd., occurs in the rain-forest of the Williams River district. This form has already been recorded from the Comboyne Plateau by Chisholm (1937), and has also been observed by the writers on the Dorrigo Plateau.

Family FLACOURTIACEAE.

*Streptothamus Beckleri* F.v.M. is found at high altitudes in northern New South Wales and Queensland. The Barrington Tops is the most southern locality from which it has been recorded. It occurs here in the sub-antarctic rain-forest associated with *Nothofagus Moorei* at an altitude of about 4,000 feet.

Family MYRTACEAE.

*Syncarpia laurifolia* Ten. var. *glabra* Benth. was described from the Hastings River (*Flora Australiensis*, III, p. 266). It is apparently a rare tree, as there is no material in the Sydney National Herbarium. A very few plants only have been observed in the Williams River rain-forest, where the normal *Syncarpia laurifolia* is common.

*Myrtus Beckleri* F.v.M. is at about its southern limit in the Williams River sub-tropical rain-forest.

*Baeckea Gunniana* Schau. var. *latifolia* Benth. occurs mainly on the Kosciusko Plateau and other southern highlands of New South Wales. It is probably at its northern limit on the Barrington Tops Plateau.

Family HALORRHAGACEAE.

*Myriophyllum pedunculatum* Hook. f. occurs in the creeks of the Barrington Tops Plateau up to about 4,800 feet. It occurs in Tasmania, and at Kosciusko, and has not previously been recorded north of the Blue Mountains.

Family ERICACEAE.

*Gaultheria appressa* A. W. Hill (*Journ. Linn. Soc. London. Bot.* xlix, 1935, p. 622).—This species had previously been included with *G. hispida* R.Br. (*Prod.*, 1810, p. 559). *G. hispida*, however, was described from Tasmania, and as it differs in several respects from the form occurring on the Australian mainland, that name is now restricted to the Tasmanian species. *G. appressa* is recorded from the Australian Alps and environs, the Blue Mountains and Barrington Tops, which is apparently its northern limit. In this district it is a common shrub at an altitude of about 4,500 feet.

Family EPACRIDACEAE.

*EPACRIS MICROPHYLLA* R.Br. var. *RHOMBIFOLIA*, n. var.—Ab typo foliis manifeste et breviter petiolaribus, plus vel minus appressis, sub-acutis nunquam acuminatis,

callo parvissimo ad summam, haud vel vix caudatis ad basem, rhomboidalibus; sepalis minus incurvatis ad corollam, et habito elatioro erectioro differt. Barrington Tops: 4,500 feet (L. Fraser and J. Vickery, 7/1/1934, Type); 5,100 feet (J. L. Boorman, 12/1915; L. Harrison, 1/1925); Wingello (J. L. Boorman, 12/1899). This variety differs from the type in the leaves, which are distinctly but shortly petiolate, more or less appressed, sub-acute with a very small callous point, never acuminate, not or scarcely cordate at the base, rather rhomboidal in shape, and in the sepals which are less incurved towards the corolla, and in the taller, more erect habit. It occurs beside creeks on the Barrington Tops Plateau usually at an altitude of 4,500-4,800 feet.

#### Family MYRSINACEAE.

*Embelia australasica* Mez, a liane of the northern sub-tropical rain-forests, occurs in the Williams River rain-forest at about its southern limit.

#### Family LOGANIACEAE.

*Mitrasacme serpyllifolia* R.Br. occurs also on the Blue Mountains and in Victoria and Tasmania. The Barrington Tops is probably the most northern locality of this species.

#### Family GENTIANACEAE.

*Gentiana diemensis* Griseb.—Specimens from the Barrington Tops differ from those of the Australian Alps in being larger and stouter, of annual habit, the lateral branches terminated by long (3-13 cm.), single-flowered pedicels, and the apex terminated by a corymb of four flowers in two opposite pairs, and by the longer calyx segments. Further study of more extensive material may show that this is a distinct variety. In New South Wales *Gentiana* spp. are only known from the Australian Alps and the Barrington Tops.

#### Family APOCYNACEAE.

*Parsonsia velutina* R.Br. has not been recorded south of the Williams River valley. It occurs in the sub-tropical rain-forests of the north coast and in Queensland.

#### Family RUBIACEAE.

*Coelospermum paniculatum* F.v.M. is a species of the northern sub-tropical rain-forests which has not been recorded south of the Williams River.

#### Family PLANTAGINACEAE.

##### PLANTAGO PALUSTRIS, n. sp. Text-fig. 2.

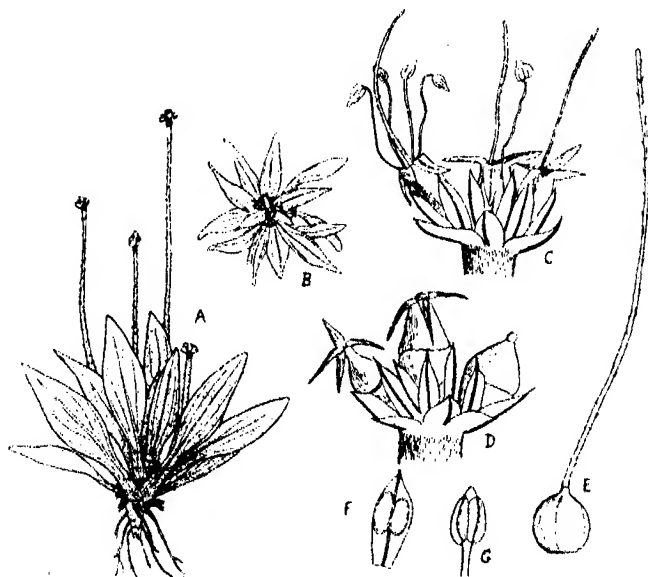
Herba perennis acaulis, collo brevissimo crasso; collum stuppis fuscis densum; folia stellatim patentia vel adscendentia, aliquando tenuia, nunquam carnosae, paulo pilosa praesertim ad basem, vel tandem glabrescentia ad summam, lanceolata, acuta, integra, 3- vel sub-5-nervata, ad basem in petiolum planum vaginatum margine scariosum contracta; laminae cum petiolis 2.5-8 x 0.4-1.5 cm.; vena prima et venae tenues laterales paulo prominentes subter; pedunculi brevissimi, 1-4 mm. longi cum floribus, postea elongati, 8-15 cm. longi cum fructibus maturescentibus, molliter pubescentes, dense pubescentes sub spicam; spica paucis- (2-6-plerumque 3-) floribus, capitata 3-5 mm. diam., stuppis inter flores; bracteoli 1-2 mm. longi, duplo breviores vel raro sub-aequilongi sepalis, late ovati, acuti, carinati, margine scariosi, glabrescentes; sepalia 4, ovata, acuta vel brevissime mucronata, carinata, 2.5 mm. longa; tubus corollae glabrescens, sepalis aequilongis, segmentis 4 acutis



angustato-ovatis, patentibus vel sub-refractis, duplo brevioribus tubo; stamina 4, exserta, filamenta sedentia ad mediam corollam; anthera 0.5 mm. longa, ovata, mucrone breve; ovarium globosum vel aliquando sub-tetragonale, 1.2 mm. diam., bilocularis, 4-ovulatum; loculus 2-ovulatus; stylus 9 mm. longus, pubescens praeter ad basem; pyxidium sub-globosum vel paulo conicum ad summam, mucro breve, 2.5-3 mm. diam., plerumque 4-seminis; semina ovalia, plana,  $2 \times 1$  mm., fulva.

*Loc.*—Barrington Tops in swamp, at 4,800 feet (L. Fraser and J. Vickery, 7/1/1934, Type).

Rosette perennial with a very short, rather thickened stem crowded with tufts of long brownish hairs; leaves stellately spreading or ascending, rather thin, never fleshy, slightly hairy, especially towards the base, or sometimes becoming almost glabrous towards the tip, lanceolate, acute, entire, 3- or sub-5-nerved, becoming narrowed at the base into the flat, sheathing petiole which has scarious margins; laminae with petioles 2.5-8  $\times$  0.4-1.5 cm.; midrib and the fine lateral veins slightly prominent on the lower surface; peduncles very short, 1-4 mm. at the time of flowering, but elongating up to about 15 cm. as the fruit matures, softly pubescent, densely so immediately under the spike; spike few- (2-6- usually 3-) flowered, capitate, 3-5 mm. diam., with tufts of hairs between the flowers; bracteoles 1.2 mm. long, shorter than or rarely subequal to the calyx, broadly ovate, acute, keeled, with scarious margins, glabrous; sepals 4, ovate, acute or very shortly mucronate, keeled, 2.5 mm. long; corolla tube glabrous, equalling the calyx, with four acute, narrow ovate, spreading or slightly reflexed segments half as long as the tube; stamens 4, exserted, the filaments fused to the corolla tube half-way down; anthers 0.5 mm. long, ovate, with a short point; style 9 mm. long,



Text-fig. 2.—*Plantago palustris*. A, plant showing elongated peduncles bearing the fruit,  $\times 0.4$ ; B, plant showing rosette form, and extremely short peduncles bearing the flowers,  $\times 0.4$ ; C, inflorescence at anthesis,  $\times 5.6$ ; D, inflorescence showing fruit,  $\times 5.6$ ; E, gynaecium,  $\times 8.5$ ; F, septum of ovary bearing two ovules,  $\times 10.8$ ; G, anther,  $\times 13$ .

pubescent except at the base; ovary globose or very slightly 4-lobed; 1.2 mm. in diam., 2-celled, with two ovules in each cell; fruit a pyxidium, sub-globose or slightly conical in the upper part, with a short point left by the base of the style, usually 4-seeded, 2.5-3 mm. diam.; seeds oval, flattened,  $2 \times 1$  mm., light brown in colour.

This species is only known from the margins of the swamps of the Barrington Tops Plateau, to which it appears to be endemic. Superficially, it somewhat resembles *P. stellaris* F.v.M., which occurs in the Australian Alps, but differs from it in the less stellate habit, in the peduncle elongating very conspicuously after pollination, the less conspicuously thick roots, the sparsely hairy and less fleshy leaves, and the four seeds in the fruit. It differs from *P. Brownii* Rapin, which is known from the Australian Alps and Tasmania, in the peduncles, which are shorter than in *P. Brownii* before pollination and much longer afterwards, and in the entire, hairy leaves and less stellate habit.

#### Family GOODENIACEAE.

*Velleia montana* Hook. f. is present at about its most northern limit. It occurs on the Blue Mountains in this State, and in Victoria and Tasmania.

#### Family COMPOSITAE.

*Cotula filicula* Hook. f. has only previously been recorded from southern New South Wales. It occurs also in Victoria and Tasmania. On the Barrington Tops it occurs in *Eucalyptus pauciflora* forest at an altitude of about 4,500 feet.

*Erigeron pappochromus* Labill. is found at high altitudes in the southern parts of the State, and in Tasmania and Victoria, and has not previously been recorded so far north.

#### Summary.

The distribution of a number of species occurring in the Upper Williams River and Barrington Tops districts is considered. Many species growing on the Barrington Tops Plateau show interesting affinities with the floras of the Kosciusko Plateau (N.S.W.) and Tasmania.

Two species, *Pollinia nuda* Trin. (exotic) and *Panicum lachnophyllum* R.Br. are recorded as new for New South Wales.

Two new species, *Lomatia arborescens* and *Plantago palustris*, and two new varieties, *Evodia micrococca* var. *pubescens* and *Epacris microphylla* var. *rhombifolia* are described. Two new combinations, *Lomandra montana* (R.Br.) and *L. Hystrix* (R.Br.) are cited.

In conclusion, the writers desire to express their thanks to Mr. R. H. Anderson, Botanist and Curator, National Herbarium, Sydney, for his help and interest during the progress of this work, and to other members of the staff of the National Herbarium and of the Botany Department, University of Sydney, for assistance in the determination of plants.

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## NOTES ON AUSTRALIAN MOSQUITOES (DIPTERA, CULICIDAE).

PART IV. THE GENUS *THEOBALDIA*, WITH DESCRIPTION OF A NEW SPECIES.

By D. J. LEE, B.Sc.

(Nine Text-figures.)

[Read 29th September, 1937.]

Five members of the genus *Theobaldia* have been described from Australasia, namely, *T. frenchi* Theo. and *T. hilli* Edw. from Victoria, *T. littleri* Tayl. and *T. wetndorferi* Edw. from Tasmania, and *T. tonnoiri* Edw. from New Zealand. In this paper a new species is described from New South Wales. It is distinct from *T. hilli*, *T. frenchi* and *T. wetndorferi* on characters of the terminalia, from *T. littleri* in having the upright scales of the head dark and the anterior pronotal lobes bare of scales or hairs, and from *T. tonnoiri* in not having the wings spotted. The presumed male of *T. littleri* is also described.

The larva of the new species is described and it is considered that its significant characters agree with those of the subgenus *Culicella* rather than with *Climacura*. The previously-described species were provisionally placed in the latter pending the discovery of their larvae.

*THEOBALDIA INCONSPICUA*, n. sp.

Head dark brown, covered with narrow curved golden scales, flat whitish ones laterally. Upright scales dark brown, paler at base, some yellowish ones in front. Proboscis dark brown with pale reflections beneath, especially at middle. Male palpi as long as proboscis, last two segments hairy. Female palpi one-eighth the length of proboscis, dark brown. Antennae of male shorter than proboscis, brown with blackish segmentation, plumes grey and creamy. Basal segment dark brown. Mesonotum bright brown with two medial paler bare lines and a pair of similar lateral spots. Scales narrow-curved and golden, fairly sparse. A few similar scales on scutellum. Border bristles 5 or 6 on each lobe. Postnotum creamy-yellow. Pleural chaetotaxy of female: Integument generally yellowish-brown. Anterior and posterior pronotal lobes devoid of scales or fine soft hairs. Four strong and several shorter bristles on anterior pronotum and 3-5 strong bristles on posterior pronotum. Two short fine spiracular hairs. No post-spiracular bristles. Sternopleura with a curved row of fine bristles and one strong one below it; patch of hairs and creamy lanceolate scales on lower part. Patch of pre-alar bristles. Two weak upper mesepimeral bristles, one strong lower one with a weaker one above it. Mesepimeron also bearing soft pale hairs, a few pale scales and a group of erect hairs on upper posterior part. Male similar to female in above characters but generally weaker in their representation. Wings: scales narrow curved, dark brown. Base of first fork cell proximal to second; r-m distal to m-cu by twice the length of m-cu. A group of hairs on base of radius beneath; fewer similar hairs in same position above. Length 3.8-4.0 mm. Abdomen unbanded, dark brown, violet reflections dorsally.

slightly paler beneath. Male terminalia: Coxite more than twice as long as broad, tapering; style with short terminal spine. Basal lobes very small and imperfectly separated from coxite, hairy at tip. Lobes of ninth tergite not prominent, with 7-10 curved bristles.

Type series bred through from larvae collected at Mittagong, N.S.W., 20/9/36, and on Tinderry Range at a height of 4,500 feet (10 miles east of Michelago, N.S.W.), 10/10/36.

Holotype ♂, allotype and paratype ♀ from Tinderry; two ♂ and one ♀ paratype from Mittagong. An additional male, from Oxford Falls, Sydney, 3/11/22, Mackerras, is in the Macleay Museum. Holotype and allotype in the museum of the Council for Scientific and Industrial Research, Canberra.

#### Presumed Male of *THEOBALDIA LITTLERI* Tayl.

Agrees with the description of the original female except in the following points. Palpi almost as long as proboscis, dark scaled. Basal segment of antenna light brown. Thorax: chaetae golden, except on scutellum where they are black. Scutellum with four border bristles on the lateral lobes and six on the central one. Wing: base of first fork cell about half the length of its cell, of second almost as long as its cell. Cross-veins r-m and m-cu equal in length but separated by only twice the length of m-cu.

Terminalia: Coxites elongated, almost three times as long as broad. Basal lobes two-thirds the length of the coxite, very distinct and well separated, giving the appearance of claspettes. A number of spines and hairs at tip. Aedeagus distinctly chitinated. Lobes of ninth tergite not very pronounced, with about 10 spines (only their points of attachment showing in specimen).

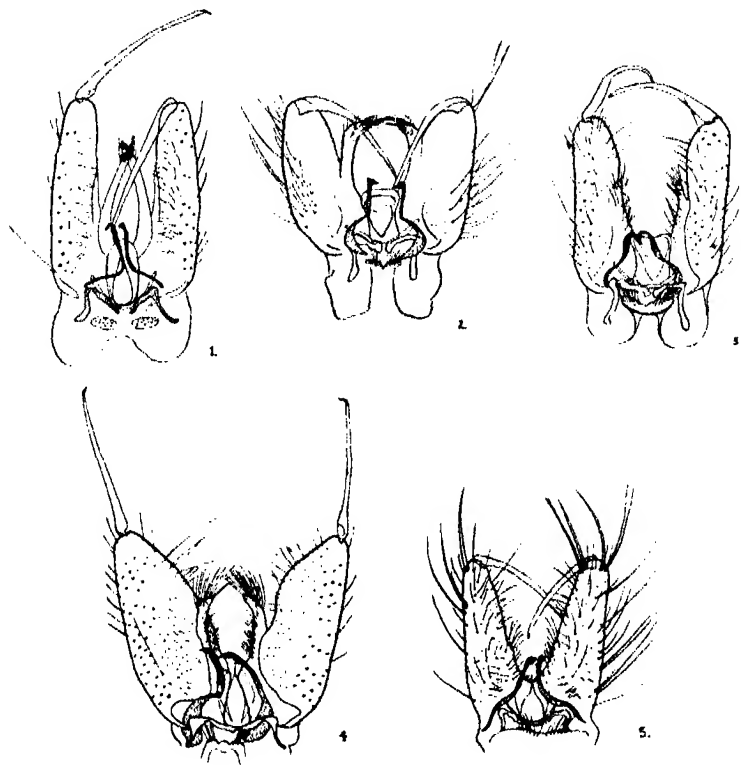
Specimen from Barrington Tops, N.S.W., Sydney University Zoological Expedition, January, 1925, in the Macleay Museum. Another specimen in the same museum, collected by I. M. Mackerras at National Park, N.S.W., 1/1/26, is identical, except that it has a darkened cloud on the wing membrane as in *T. frenchi*.

#### Notes on Other Species.

The male of *T. inconspicua*, n. sp., can readily be distinguished from the other species for which males have been described, namely, *T. frenchi*, *T. hilli* and *T. weindorferi*. As the terminalia of these species have only been verbally described, the opportunity is now taken to figure them. The terminalia of the type of *T. weindorferi* were remounted and drawn and the same was done with a specimen of *T. frenchi* determined by Edwards. The preparation of *T. hilli* was made from a specimen in the Macleay Museum from Beaconsfield, Victoria (G. F. Hill, 8/12/23). *T. littleri* is distinct from all the other species in having its basal lobes more fully developed and with a group of stout spines at the tip. In *T. hilli* the basal lobes reach almost to the tip of the coxite. *T. weindorferi* and *T. frenchi* have the basal lobes reaching slightly more than half-way, but they are more pronounced in the former, being more separated and hairy. The aedeagus is larger and more heavily chitinated in *T. frenchi* and the lobes of the ninth tergite bear a large number of hairs instead of a group of about 6 as in *T. weindorferi*. *T. inconspicua* has its basal lobes very greatly reduced, the lobes of the ninth tergite with 7-10 curved bristles and the aedeagus only chitinated at the tip.

The characters available for separating the females are not so satisfactory. *T. tonnotri* is apparently unique in having the wing scales variable in colour, giving the wing a spotted appearance. *T. frenchi* has a darkened cloud on the

wing membrane, but it is considered that this character is of little value in distinguishing this species. The other species have clear wings with scales uniformly coloured. *T. tonnoiri*, *T. littleri*, *T. frenchi* and *T. hilli* all have either scales or hairs on the anterior pronotal lobes, but in *T. weindorferi* and



Text-figures 1-5.—1. Terminalia of presumed male of *T. littleri* Tayl. 2. Terminalia of *T. hilli* Edw. 3. Terminalia of *T. weindorferi* Edw. 4. Terminalia of *T. frenchi* Theo. 5. Terminalia of *T. inconspicua*, n. sp. (All figures drawn to same magnification.)

*T. inconspicua* these lobes are bare of scales or hairs. *T. weindorferi* and *T. inconspicua* may be distinguished by the number of scutellar bristles (the bristles taken into account are the border bristles arising from prominent dark basal rings). In *T. weindorferi* the lateral lobes have 6-8 bristles and the central lobe 8-10. *T. inconspicua* has 5-6 on each lobe. *T. littleri*, *T. hilli* and *T. frenchi* are more difficult to separate, but the first has only pale upright scales on the head, whereas in the other two species they are at least dark towards the neck. I have no definite females of *T. hilli* before me, so am unable to judge the usefulness of the characters given by Edwards (1926) which mainly concern the colour of the pleural integument.

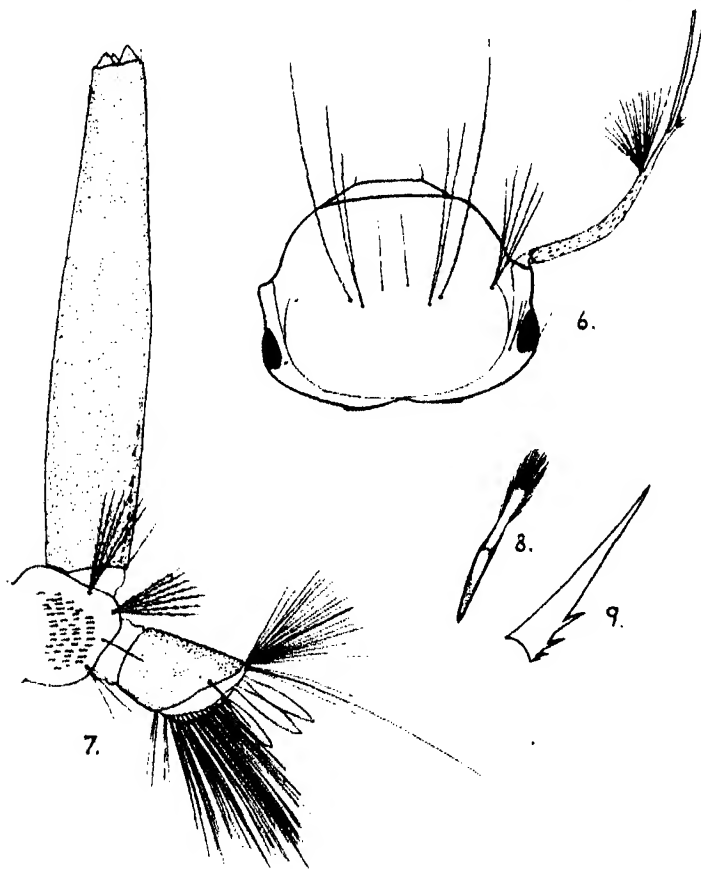
On the basis of the above characters the following key would serve to distinguish the females of the Australasian species of *Theobaldia*.

- |   |   |
|---|---|
| 1. No scales or hairs on anterior pronotal lobes .....  | 2 |
| Anterior pronotal lobes with scales or fine hairs ..... | 3 |

2. Scutellum with 6-8 border bristles on lateral lobes, 8-10 on central ..... *T. weindorferi* Edw.  
 Scutellum with 5-6 border bristles on each lobe ..... *T. inconspicua*, n. sp.  
 3. Wing spotted ..... *T. tonnoiri* Edw.  
 Wing not spotted (may have darkened patch on membrane) ..... 4  
 4. Upright scales of head all pale ..... *T. littleri* Tayl.  
 Upright scales of head dark at least towards neck .... *T. hilli* Edw.; *T. frenchi* Theo.  
 No satisfactory characters have been established to separate *T. hilli* and *T. frenchi*.

The Larva of *THEOBALDIA INCONSPICUA*, n. sp.

Head large, pale; antennae long, curved, spinose, with tuft of plumose hairs at about two-thirds from the base, one long spine arising from the tip and a pair of similar length arising sub-apically. Some of the frontal hairs spinose, ante-antennal tuft plumose. Mouth brushes bushy, labial plate with 12 teeth on either side of apical one. Thorax: Hairs well developed, except the propleural group. Meso- and meta-pleural groups plumose. Eighth abdominal segment: Comb teeth



Text-figures 6-9.—Larva of *T. inconspicua*, n. sp. 6, Head; 7, Posterior end; 8, Comb tooth; 9, Pecten spine.

in a large patch, sub-siphonal and sub-anal tufts plumose. *Siphon* long (2 mm.), devoid of hairs except for a single one near base of pecten. Pecten a row of 9 serrate teeth on basal fourth of siphon. *Anal segment*: Outer dorsal hair with one long and two short branches. Anal papillae fairly long, pointed. Ventral beard of about 12 tufts of simple hairs and also 1 or 2 arising anteriorly to the barred area.

On the characters given by Edwards (1932) for the differentiation of the subgenera of *Theobaldia*, the larva of *T. inconspicua*, n. sp., belongs to the subgenus *Culicella*. It is distinct from *Ulimacura* in having only a single pair of hairs situated basally on the siphon, in the outer dorsal hair of the anal segment being branched, the papillae long and pointed and in having 1 or 2 tufts of the ventral beard before the barred area.

As the adult of *T. inconspicua*, n. sp., is evidently closely related to those of the previously-recorded species, it is considered probable that these will also be found to belong to the subgenus *Culicella* when their larvae are discovered.

#### Acknowledgements.

My thanks are due to Dr. I. M. Mackerras for advice in the preparation of this paper, and to Mr. K. E. W. Salter for the loan of specimens from the Macleay Museum, Sydney.

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## NOTES ON AUSTRALIAN ORCHIDS. III.

## A REVIEW OF THE GENUS CYMBIDIUM IN AUSTRALIA. II.

By the REV. H. M. R. RUPP, B.A.

(Three Text-figures.)

[Read 27th October, 1937.]

I am still unable to throw any light on two species mentioned three years ago (these *Proc.*, ix, 1934, 93) as having been published as Australian—Fitzgerald's *C. gomphocarpum* and Klinge's *C. queentianum*. Fitzgerald described *C. gomphocarpum* (*Journ. Bot.*, xxi, p. 203), but gave no clue whatever to the locality, and he did not—so far as is known—figure the plant. His description of the inflorescence—"flowers in dense racemes of about twenty to thirty, green tinged with olive"—suggests the North Queensland form of *C. suave* R.Br., which differs considerably from southern forms, but does not agree with Fitzgerald's description in some essential particulars.

## CYMBIDIUM HILLII F.V.M.

*Fragm.*, xi, 88. See also Bailey, "Queensland Flora", v, p. 1547.

So far as I can ascertain, the only existing herbarium specimen of this species is an imperfect one (a leaf and a small part of a flowering raceme) in my own possession. Inquiries for *C. Hillii*, which was discovered many years ago by Walter Hill in the Mulgrave Range, N. Queensland, met with no satisfactory response. Mr. W. F. Tierney, of Cairns, was at one time under the impression that he had secured a plant, but the specimens sent were irreconcilable with the descriptions. In September, 1932, Mr. Charles Barrett sent me a specimen from a plant obtained on the Daly River. After making a careful examination I came to the conclusion that this plant must be *C. Hillii*. Affinity with *C. canaliculatum* R.Br. was obvious, but the differences were quite striking. The perianth segments are longer and narrower, and the mid-lobe of the labellum is much longer, than in *C. canaliculatum*. The mid-lobe in Mr. Barrett's flowers agrees exactly with Mueller's words in Regel's *Gartenflora*, 1879, p. 138: "lobo supero semilanceolato acuminato fere ter longiore quam lato". Mueller and Bailey are both silent about capsules. Mr. Barrett sent me one. The dimensions are as follow: Pedicel  $2\frac{1}{2}$  cm. From base of capsule to base of withered flower at apex,  $5\frac{1}{2}$  cm. Diameter at base, 2 mm.; at middle, 14 mm.; at 2 cm. from apex, 15 mm.; at apex, 5 mm. Sutures 3, closed under 3 flat-surfaced longitudinal bands, the intervening sections prominently keeled. Thus the capsule is definitely distinct from that of *C. canaliculatum*. Dimensions of one dissected flower: Sepals  $21 \times 4\frac{1}{2}$  mm.; petals  $19 \times 4$  mm.; labellum  $16\frac{1}{2} \times 5$  mm. across lateral lobes; mid-lobe  $10 \times 4$  mm.; column 11 mm. from base to top of anther. The leaf of *C. Hillii* is prominently 3-nerved.



## CYMBIDIUM IRIDIFOLIUM Cunn.

*Bot. Reg.*, 1839, Misc. 34; *C. albuciflorum* F.v.M., *Fragm.*, i, p. 188; *C. madidum* Lindl., *Bot. Reg.*, xlii, 1840, Misc. 9.

This plant, which attains great bulk, and is often found on trees in close association with epiphytic ferns, extends from the neighbourhood of the Macleay River in New South Wales (it may possibly occur a little further south) northward into the Queensland tropics. When not in flower it resembles many of the large-flowering exotic species. The racemes, however, are small-flowered and rather disappointing. In New South Wales and South Queensland I have found very little departure from what is regarded as the type form. In view of the difficulties which appear in North Queensland forms, I append a description of this southern form: A large plant, on trees along the coastal belt. Stems usually more or less hidden under the large pseudobulbous growth of the swollen imbricate bases of the leaves. Leaves 4 to 8 together, from 30 to as much as 90 cm. long, membranous and somewhat flaccid (but firmer than in *C. suave*), light green. Racemes from 20 to 60 cm. long, number of flowers very variable. Flowers thick and rather rigid, brownish outside, chiefly olive-green within, fragrant, about  $2\frac{1}{2}$  cm. from tip to tip of segments. Labellum with 2 very small lateral lobes and a large yellowish obtuse midlobe. Lamina without ridges, but glandular-sticky and shining along the median line. Column truncate, with an angle in front.



Text-figures 1-3.

1.—*C. iridifolium* Cunn. 2.—*C. suave* R.Br. 3.—Contours (enlarged) of labella of *C. suave*, to show gradations of lobation. Drawn from actual specimens.

Figs. 1 and 2 greatly reduced.

In 1932 I received from Mr. W. F. Tierney, of Cairns, several racemes of a *Cymbidium* in his possession, which he thought might be *C. Hillii*. The flowers were quite irreconcilable with descriptions of that species, but had affinities with *C. iridifolium*. They were, however, uniformly brownish, with darker blotches on

the perianth. The labellum appeared to agree precisely with Rendle's description of *C. Leai* (*Journ. Bot.*, xxxvi, p. 221), and since no other known Australian species has the peculiar form of labellum described by Rendle, I concluded that Mr. Tierney's plant must be *C. Leai*, which was absorbed by F. M. Bailey into *C. canaliculatum*. Rendle considered *C. Leai* close to *C. canaliculatum*, while Mr. Tierney's plant was nearer to *C. iridifolium*. Further material was sent in 1933 and again in 1934, and was obtained from the same plant as that of 1932, but the flowers were quite different! They were in every respect identical with those of the southern type form of *C. iridifolium*; and none had the peculiar labellum associated with *C. Leai*. The mystery of this remains unsolved, and I do not feel justified in disturbing Bailey's treatment of *C. Leai* at present.

What I have called the southern type form of *C. iridifolium* certainly extends into North Queensland, and I possess a healthy plant from Proserpine. But it is very different from the form commonly known about Cairns as *C. iridifolium*, though the differences are not structural. The Cairns *C. iridifolium* has straighter and more rigid racemes, with numerous flowers rather densely massed. The individual flower has narrower segments, much more widely expanding and, except for the yellowish apex of the labellum, it is of a uniform very pale green, inside and out. Structurally the two forms are so nearly identical that it would be unwise to separate them; but they are very distinct in appearance.

Mr. Kenneth MacPherson, of Proserpine, has contributed valuable observations on the pollination of *C. iridifolium* (*North Queensland Naturalist*, April, 1935, p. 26). A small native bee, identified by Mr. Tarleton Rayment as *Trigona cockingsi* (Ck'll), visits the flowers and carries away the viscid exudation of the labellum, apparently to be used as "bee glue" in closing small cracks, etc., in its nests. In the course of the operation, which was watched by Mr. MacPherson repeatedly, the labellum moved up and imprisoned the bees against the column. The bees, struggling to free themselves, invariably burst the anther-sacs, and escaped bearing a supply of pollen on their backs, to be deposited on the stigmatic plates of other flowers.

#### CYMBIDIUM SUAVE R.Br.

*Prodr.*, 331. (See also Benth., *Fl. Austr.*, vi, 303; Bailey, *Q. Fl.*, v, 1548; Rupp, *Guide to Orch. N.S.W.*, 47 [photograph].) References indicate that in one important matter botanists have not adhered strictly to Robert Brown's description. Brown explicitly states of the labellum, "indiviso". Bentham and Bailey include within the species forms having the labellum "obscurely sinuate 3-lobed". A careful study of forms ranging in habitat from North Queensland to the South Coast of New South Wales—a study embracing both living plants and dried specimens—has convinced me that we must go even further than Bentham and Bailey, and include forms with a labellum as definitely trilobate as that of any other Australian species. In this respect *C. suave* is extremely variable, and the form of the labellum is too inconstant to be relied upon as a guide to determination. The process of lobation can be traced through all stages. What we must call the type form, with a labellum perfectly entire, is—except in North Queensland—much less common than the variants. In some cases a very slight swelling on both margins of the lamina is an indication of tendency to lobation; other flowers will be found with these swellings quite prominent; in others they have become Bentham's "obscurely sinuate" lobes; and so on, till we reach a form of labellum as well lobed as that of *C. iridifolium*. I do not think it would be wise even to constitute a var. *lobatum*, because the intermediates are so many that confusion would result.

Bentham describes the flowers of *C. suave* as "green, blotched with red". Brown says nothing of this; and it is certainly not typical. I have seen this form once. A plant which I obtained many years ago at Lillyvale, in the Illawarra district of New South Wales, had dull green flowers with reddish blotches. Though *C. suave* is abundant in many districts, I have only been able to find three people besides myself who have seen this form with blotched flowers. The commonest colouring, in New South Wales and South Queensland, is a delicate golden-green, the perianth sometimes brown on the outside, especially in bud. The flowers are deliciously fragrant.

A large plant of *C. suave* may reach a diameter of 90 cm. or more, but, generally speaking, it is not as bulky as other species. It lacks the bulbous swelling at the base of the leaves which is so prominent in *C. canaliculatum* and *C. iridifolium*, but has much longer stems, which are covered with ragged fibre—the remnants of dead leaf-bases. The leaves are bright green, narrow, and very flexible, from 16 to 50 cm. in length. The racemes are variable in length: in the North Queensland form they are (at least in all specimens sent to me) only about 13 cm. long, with densely packed very pale green flowers. Southern racemes attain 30 cm., but the average would be about 21.

Fitzgerald's *C. gomphocarpum*, as far as one can judge from his description, must be closely allied to forms of *C. suave* with a lobed labellum. It is distinguished by its "club-shaped or almost terete" capsule—that of *C. suave* being oval or almost globular. There is an unpublished Fitzgerald plate in the Mitchell Library at Sydney, depicting a *Cymbidium* from Cook's River, near Botany Bay. No name is attached, but it appears to be *C. suave* with a lobed labellum. It is curious that Robert Brown never saw this form, for it is quite common—or was a few years ago—in the central coastal area of New South Wales. The range of *C. suave* from north to south is probably more than 2,000 miles. It is restricted to the coast districts and the Dividing Range, and has only been found in Queensland and New South Wales.

In Part I of this review I alluded to the habit of Australian *Cymbidiums* of rooting in the hollows of decayed branches of trees. This habit, as far as I can ascertain, is invariable in the case of *C. canaliculatum*, but I find that it is by no means so with *C. iridifolium* and *C. suave*. The former grows freely with its roots embedded in masses of *Platycerium* (stag-horn and elk-horn ferns), while *C. suave* sometimes occurs rooted in the paper-bark of *McLaleuca leucadendron* and other tea-trees, or on trunks of tree-ferns.

I have already acknowledged, in Part I, the kind assistance received from many quarters during my investigations of *C. canaliculatum*, and I need only add here that it has been continued during the past three years while I have been endeavouring, with only partial success, to secure fuller information concerning other Australian species.

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## THE OCCURRENCE OF GRAPTOLITES NEAR YASS, NEW SOUTH WALES.

By KATHLEEN SHERRARD, M.Sc., and R. A. KEBLE, F.G.S., Palaeontologist to the National Museum, Melbourne.

(Plate xv; twenty-five Text-figures.)

[Read 27th October, 1937.]

Graptolites of both Upper Ordovician and Silurian age have been found near Yass. Upper Ordovician assemblages were discovered in slates at several localities in the Parishes of Morumbateman, Mundoonen and Manton in the Yass River District, all situated between 12 and 15 miles east of Yass and near the Yass-Gundaroo road (Sherrard, 1936b). These graptolites of Upper Ordovician age were found in rocks hitherto mapped as Silurian, which age was probably assigned to them on account of their comparative proximity to beds carrying Silurian fossils near Yass. No other fossils were found with the graptolites.

Silurian graptolites occur at a locality known as Silverdale, seven miles to the north-west of Yass (see Text-fig. A), where several species of *Monograptus* have been obtained (Sherrard, 1934, 1936a). All were found in one small outcrop, which also yielded brachiopods, crinoid stems and traces of trilobites.

### Upper Ordovician Beds.

These beds are blue and grey shaly slates, all dipping at high angles, 50 degrees and more, and striking between north-west and west-south-west. The slates cleave easily, but have not the fissile cleavage of roofing slates. In some cases they are puckered and contorted, while in others mineral solutions have penetrated freely along the bedding planes, probably often obscuring graptolites. In some specimens the material of which the graptolite impressions consists has been dissolved away, leaving merely an unidentifiable negative impression, surrounded by a white film.

The graptolites found at the various localities are:

Loc. 1.—Portion 24, Parish of Morumbateman, on Yass-Gundaroo road, 100 yards west of 12th mile-post: *Climacograptus bicornis* Hall, *C. missilis* Keble and Harris, *Diplograptus* (*Orthograptus*) *calcaratus* Lapworth.

Loc. 2.—Portion 1, Parish of Mundoonen, 200 yards north of Morumbateman road junction: *Diplograptus* (*Orthograptus*) *calcaratus* Lapw. var. *basilicus* Lapw., *D. cf. truncatus* Lapworth, *D. sp. indet.*, *Climacograptus missilis* Keble and Harris, *C. sp. indet.*, *Cryptograptus tricornis* Carruthers, *Retiograptus yassensis*, n. sp., *Dicellograptus cf. complanatus* Lapworth, *D. cf. sextans* Hall, *D. sp. indet.*

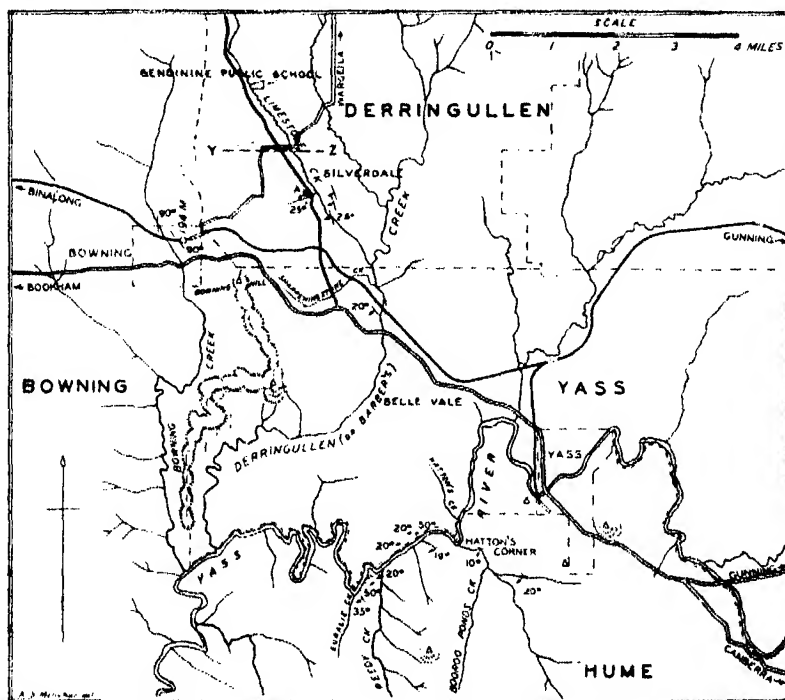
Loc. 3.—Portion 152, Parish of Manton; about centre of Portion, 50 yards north of Yass River: *Dicellograptus elegans* Carruthers, *D. cf. complanatus* Lapworth, *D. cf. moffatensis* Carruthers, *D. cf. pumilus* Lapworth, *D. cf. sextans* Hall, *D. cf. smithi* Ruedemann, *D. sp. indet.*

Loc. 4.—Portion 61, Parish of Manton, eastern half: *Dicellograptus divaricatus* Hall var. *rigidus* Lapworth, *D. cf. complanatus* Lapworth, *D. elegans* Carruthers, *D. sp. indet.*, *Diplograptus* (*Orthograptus*) *calcaratus* Lapworth var. *basilicus*

Lapw., *Climacograptus missilis* Keble and Harris, *C. tubuliferous* Lapworth, *C. sp. indet.*

Loc. 5.—Reserve, No. 43134, Parish of Morumbateman, at waterfall, about half a mile west of junction between Portions 94 and 150, Parish of Morumbateman: *Diplograptus* (*Orthograptus*) *calcaratus* Lapworth var. *basilicus* Lapw.

Loc. 6.—Portion 31, Parish of Morumbateman, near NW. corner, 50 yards south of Yass River: Graptolite fragments indeterminate.



Text-fig. A.—Topographical Map of Area between Yass and Bowning.

A = Graptolite locality.

(See Sherrard, 1936a, Text-fig. 9, for Geological Sketch-Map of the Yass and Bowning districts.)

The accompanying table attempts to correlate the graptolite species found in other parts of New South Wales, in Victoria, in Great Britain and in North America with those of Upper Ordovician age found in the Yass River district. On the whole the correlation is satisfactory. The discordant species are *D. cf. sextans*, since this species is never found higher than the Glasbornian in Victoria and in a very similar association in Great Britain and America, and *D. cf. complanatus*, which species, in Victoria, is never found outside the Bolindian. Possibly the discordance is due to the fact that the Australian Dicellograptidae have not been adequately described and figured. When a close examination of the forms referred to these discordant species is made, they will probably exhibit those small differences so often found in Australian species at first glance conspecific with the British.

Correlation of Upper Ordovician at Yass, N.S.W., with other Outcrops.

	Victoria.				Britain.				N. America.				Other N.S.W. Localities.				
	(Libornian). <sup>1</sup>	(Rusconian). <sup>1</sup>	(Rollindian). <sup>1</sup>	Zone 9. <sup>2</sup>	Zone 10. <sup>2</sup>	Zone 11. <sup>2</sup>	Zone 12. <sup>2</sup>	Zone 13. <sup>2</sup>	Normanskill. <sup>3</sup>	Masson. <sup>4</sup>	Utica. <sup>5</sup>	(County Wallasey). <sup>6</sup>	Manburra. <sup>7</sup>	Houlburn. <sup>8</sup>	Queanbeyan. <sup>9</sup>	Tonkinley (Peak Hill). <sup>10</sup>	(Tullahoma). <sup>11</sup>
<i>Climacograptus bicornis</i> ..	X	X	X	X	X	X	X		X	X	X	X	spp. incert.				X
<i>C. tubuliferus</i> ..		X	X				X	X				X			X	X	cf.
<i>C. misaria</i> ..		X	X														
<i>Diplograptus (Orthograptus) calcaratus</i> ..	X	X	X		X	X	X	X	X			other sp.	spp. incert.	var.			other sp.
<i>D. (Orthograptus) calcaratus</i> var. <i>hostilis</i> ..	X	X	X				X	X									
<i>D. cf. truncatus</i> ..	X	X	X				X	X									an- other sp.
<i>Retiograptus yassensis</i> ..	X																
<i>Dicellograptus cf. exilis</i> ..	X	X		X	X				X					sp. indet.			
<i>D. cf. complanatus</i> ..			X														var.
<i>D. dicarctatus</i> var. <i>rigidus</i> ..	X			X	X	X?			X			cf.				cf.	X
<i>D. elegans</i> ..	X	X	X				X	X									
<i>D. cf. moffettensis</i> ..	X	X	X	X	X	X			var.								
<i>D. cf. pumilus</i> ..	X		X		X	X	X	X									
<i>D. cf. smithi</i> ..	X								X								
<i>Cryptograptus tricarinatus</i> ..	X	X	X	X	X	X	X		X	X							X

Notes on table: <sup>1</sup> Thomas and Keble, 1933. <sup>2</sup> Elles and Wood, 1913. <sup>3</sup> Ruedemann, 1903. <sup>4</sup> Hall, T. S., 1902. <sup>5</sup> Naylor, 1935. <sup>6</sup> Harris and Keble, 1929. The specimens described in this paper were obtained from Queanbeyan, N.S.W., just outside the Federal Capital Territory. <sup>7</sup> Hall, T. S., 1909, 1920.

A more precise correlation with the Victorian series, ignoring, for the time being, the discordant element, is as follows:

Loc. 1.—Top of Eastonian or base of Bolindian.

Loc. 2.—Eastonian, probably high. Limiting species, *Cryptograptus tricornis*, the extreme upward range of which is the top of the Eastonian, and a number of Eastonian-Bolindian forms.

Loc. 3.—Eastonian, probably high.

Loc. 4.—Top of Eastonian or base of Bolindian.

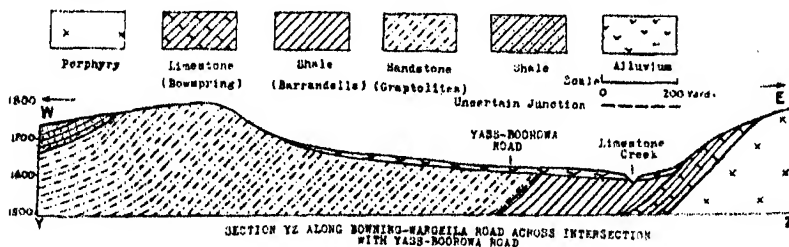
Loc. 5.—Probably Eastonian.

Loc. 6.—Indefinite.

Thomas and Keble state (1933) that the Eastonian embraces approximately the lower two zones of the Caradocian, and the Bolindian corresponds to the zone of *Pleurograptus linearis* and to the Ashgillian of Britain. It may be stated, therefore, that the Yass Upper Ordovician beds correspond to parts of the Caradocian of Britain.

#### Silurian Beds.

Graptolites of Silurian age occur in ripple-marked, medium-grained, greenish-brown, probably tuffaceous sandstone outcropping on the crest of a hill in Portion 34, Parish of Derringullen, County of King, included among the Lower Trilobite Beds of Mitchell (1886, 1888). The outcrop is about 300 yards west of a point on the Yass-Boorowa road, which point is three-quarters of a mile north of the Sydney-Melbourne railway crossing. This locality is known as Silverdale from a property of that name nearby. The graptolite bed dips at 25 degrees to the south-west and overlies shales dipping 25 degrees west-south-west. These



Text-fig. B.—Section along line Y-Z, Text-fig. A.

shales, which outcrop in the bed of Limestone Creek, a quarter of a mile to the east (see locality map, Text-fig. A), are richly fossiliferous, though without graptolites. They contain numerous forms identical with those in the Barrandella shales at Hatton's Corner, 6 miles to the south-south-east. Shearsby (1911) and one of the authors (Sherrard, 1936a) consider the Limestone Creek shales an extension of the Barrandella shales at Hatton's Corner, and Shearsby (1911) has given a list of the Limestone Creek fauna. Cuttings in the road from Wargella to Bowning, which runs east and west and crosses the Yass-Boorowa road three-quarters of a mile north of the graptolite outcrop, reveal gentle south-west to west-south-west dips. As one travels along this road from a limestone outcrop (Bowspring) in the east, over the Barrandella shales in the bed of Limestone Creek, to the sandstones on the horizon of the graptolite bed, these gentle dips persist (Section Y-Z, Text-fig. B), leaving no doubt that the graptolite bed overlies the Limestone Creek beds and incidentally the Barrandella shales. There is no indication or suggestion of faulting or thrusting; the succession seems to be quite conformable and undia-

turbed. Hence the age of the Limestone Creek beds and the Barrandella shales, if Shearsby and Sherrard are right in stating that they are the same bed, may be fixed by the graptolite bed, that is, they are Silurian, probably high Wenlockian.

The brachiopods which frequently are found on the same slab as the graptolites, are all small, suggesting an unfavourable environment. *Stropheodonta davidi*, for instance, has a width of 4 mm. across the brachial valve and a length of 2.5 mm., while the type is recorded with a width of 6.0-6.3 mm. and a length of 4.8 mm. (Mitchell, 1923). While the form referred to as *Atrypa* sp. is somewhat similar to *A. pulchra* Mitchell and Dun (1920), it is very much smaller than that species, being only 3.5 mm. in width and 2.5 mm. in length in a typical specimen.

The following forms have been recognized from the graptolite bed at Silverdale: *Monograptus Flemingii* (Salter), *M. cf. tumescens* Wood, *M. cf. nilssoni* (Barrande), *M. cf. vomerinus* (Nicholson), *Dictyonema* sp., *Nucleospira australis* McCoy, *Stropheodonta davidi* (Mitchell), *Atrypa fimbriata* Chapman (?), *A. sp.*, *Merista* sp., trilobite fragments, crinoid stems.

The graptolites indicate Zones 26 to 35 of the Silurian as divided by Elles and Wood (1913), which makes the bed at Silverdale containing them equivalent to the Wenlock-Ludlow junction beds of England, and to the Melbourne Series of Victoria (Chapman and Thomas, 1935; Keble and Harris, 1934).

Specimens of *Monograptus* described by T. S. Hall (1903) as "allied to *M. dubius*" were obtained by Mitchell from Belle Vale, Yass, which is a property situated between Silverdale and Hatton's Corner (see locality map, Text-fig. A).

Shearsby (personal communication) obtained a specimen identified as *Monograptus cf. vomerinus*, while quarrying operations were in progress about 1915 for a new railway bridge over Bowning Creek near Bowning Station, 2½ miles west of Silverdale (see Text-fig. A).

Species of *Monograptus* obtained near Goulburn, about 60 miles east of Silverdale (Naylor, 1935), are the only other forms of Monograptidae described from New South Wales. At that locality all species but one are characteristic of beds of Lower Silurian age.

#### FAMILY DIPLOGRAPTIDAE Lapworth.

##### CLIMACOGRAPTUS BICORNIS (Hall). Text-fig. 1.

A rhabdosome 1.2 cm. in length is exposed which is incomplete distally. Its width is 1 mm. at the proximal end and 2.2 mm. where it is broken distally. The spines are very strong and conspicuous, 6 mm. in length and include an angle of 110 degrees. The sicula is inconspicuous. There are 10 thecae in 10 mm., about 1.5 mm. long and overlapping one-third of this length. Their apertural margins are situated within horizontal pouches which occupy nearly one-third the width of the rhabdosome. The ventral edges of the thecae are straight and vertical. The septum is preserved complete except at the extreme proximal end.

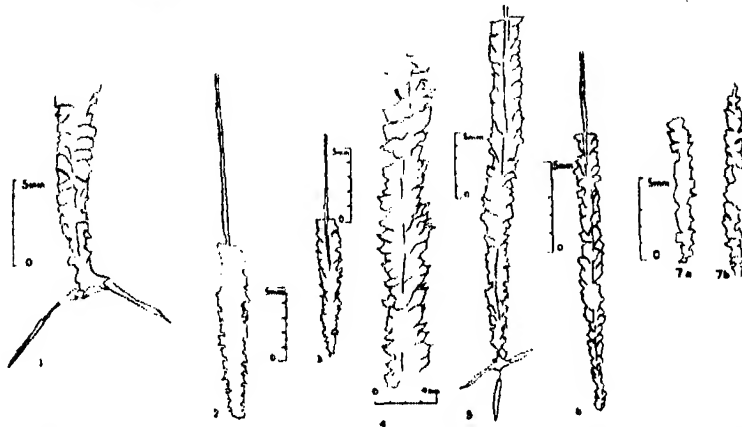
##### CLIMACOGRAPTUS TUBULIFEROUS Lapworth. Pl. xv, fig. 3; Text-fig. 2.

Rhabdosome 1.2 cm. in length, increasing in width slowly from 0.8 mm. to just over 2 cm. distally. The sicula is not seen. There are 12 thecae in 10 mm., the free edge of the theca is straight or slightly concave and the apertural margin lies within a semicircular excavation which occupies one-fifth the width of the rhabdosome. The virgula is very conspicuous, and about 0.5 mm. wide. It is prolonged 10 mm. beyond the distal extremity of the rhabdosome, within which it can be detected for a short distance. Short spines are visible on the mesial angles of some of the thecae.



**CLIMACOGRAPTUS MISSILIS** Keble and Harris. Text-fig. 3.

Rhabdosome not more than 1 cm. in length. Its width, less than 1 mm. proximally, increases to nearly 2 mm. distally. A short virgella is visible. The virgula can be seen in the body of the rhabdosome for one-third of its length, of which 6 mm. projects at the distal end, and is somewhat expanded in places. Thecae 10-11 in 10 mm., about 1.5 mm. long, of which one-third to one-half overlaps. The apertural margin lies within an excavation occupying one-quarter the width of the rhabdosome.



Text-fig. 1.—*Climacograptus bicornis* (Hall), Portion 24, Parish of Morumbateman. No. S.516.

Text-fig. 2.—*Climacograptus tubuliferous* Lapworth, Port. 61, Par. of Manton. No. S.591.

Text-fig. 3.—*Climacograptus missilis* Keble and Harris, Port. 24, Par. of Morumbateman. No. S.502.

Text-fig. 4.—*Diplograptus* (*Orthograptus*) cf. *truncatus* Lapw., Port. 24, Par. of Morumbateman. No. S.505.

Text-fig. 5.—*Diplograptus* (*Orthograptus*) *calcaratus* Lapworth, Port. 24, Par. of Morumbateman. No. S.502.

Text-fig. 6.—*Diplograptus* (*Orthograptus*) *calcaratus* Lapworth, var. *basilius* Lapworth, Port 61, Par. of Manton. No. S.578.

Text-fig. 7.—*Cryptograptus tricornis* (Carruthers), Port. 1, Par. of Mundoonen. No. S.507. 7a, obverse aspect, obliquely compressed; 7b, same aspect, normally compressed, on same slab as 7a.

**DIPLOGRAPTUS (ORTHOGRAPTUS) cf. TRUNCATUS** Lapw. Text-fig. 4.

Rhabdosome incomplete, fragments of 2 cm. preserved, reaching a maximum width of more than 3 mm., but becoming slightly narrower distally. Thecae 10 in 10 mm., and 2 mm. long, overlap, according to aspect of preservation, is one-third or one-half of this length. The apertural margin is undulate and everted, and the overlap of one theca upon the next is very plain. Septum discontinuous.

**DIPLOGRAPTUS (ORTHOGRAPTUS) CALCARATUS** Lapworth. Text-fig. 5.

The rhabdosome is 3-4 cm. in length and increases in width from 1.0 mm. to 2.5 mm., which is attained about 1.5 cm. from the proximal extremity. The virgella is very conspicuous and about 4 mm. long. Strong spines, only slightly shorter, are developed on the first two thecae. The virgula is broad. It is

observable within the body of the rhabdosome and is sometimes prolonged beyond the distal extremity of the rhabdosome, though it is frequently broken off short in the specimens observed. Thecae 8-10 in 10 mm., about 2 mm. long, overlap about one-half this length. According to the aspect of preservation which is sometimes scalariform in the proximal portion and sub-scalariform distally, the thecae vary in appearance. Their outlines may be rounded or have a parallel inclination. The septum is discontinuous.

DIPLOGRAPTUS (ORTHOGRAPTUS) CALCARATUS var. BASILICUS Lapworth. Text-fig. 6.

A variety of *Diplograptus calcaratus* occurs more abundantly than the type form. It is without the prominent basal spines, and is rather narrow and compact, its maximum width being 2 mm. The rhabdosome is 2.5 cm. in length, while the virgula projects 0.5 cm. beyond the distal extremity of the rhabdosome as well as being visible within it. There are 10 thecae in 10 mm., each being about 2 mm. long and overlapping more than half this length. There is a septum.

CRYPTOGRAPTUS TRICORNIS (Carruthers). Text-fig. 7a, 7b.

Rhabdosome a thin film, 1 cm. long, and up to 1.3 mm. wide. Thecae 12-11 in 10 mm., 1 mm. long and overlapping one-half of this length, with free edge rounded off and apertural edges everted. Proximal end not seen. Figures 7a and 7b show obverse aspect, 7a, however, being obliquely compressed.

Family DICRANOGRAPTIDAE Lapw.

DICELLOGRAPTUS cf. COMPLANATUS Lapworth. Text-fig. 8.

Stipes 3-4 cm. in length diverging at angles of 270-295° from a conspicuous sicula and with short and stout lateral spines. Thecae 11-10 in 10 mm. The proximal thecae have their ventral walls inclined, but those developed after the third or fourth theca have their ventral walls straight and in some cases parallel to the dorsal margin of the rhabdosome. The thecae overlap for about one-third their length, which is up to 2 mm. Apertures open within well-marked excavations occupying nearly half the width of the stipe and one-fifth to one-third the ventral wall. Proximally the stipes are 0.7 mm. wide, but this increases abruptly to 1.0 mm. They are straight. The axil is wide and square. The sicula is generally broken in the specimens examined, but is distinct. The shape of the axil might suggest a comparison with *D. elegans*, but this is precluded by the shape of the thecae and the straightness of the stipes. When preserved in a scalariform aspect the stipes are narrower and the angle of divergence is larger.

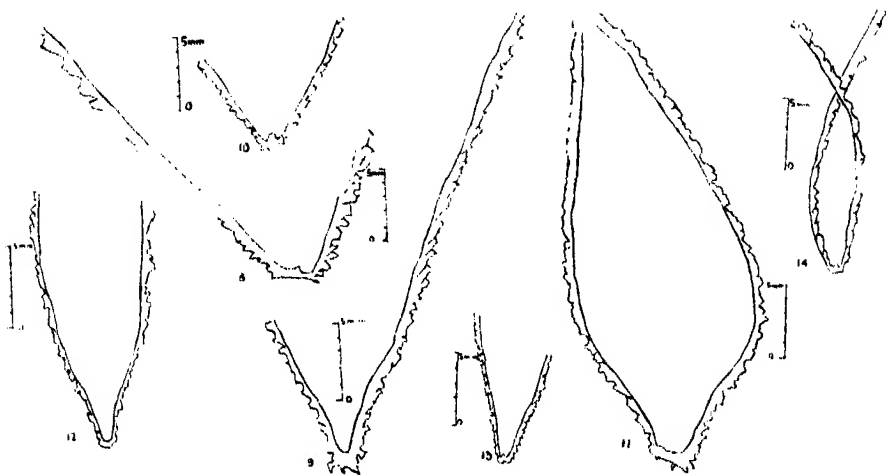
DICELLOGRAPTUS DIVARICATUS Hall var. RIGIDUS Lapworth. Text-fig. 9.

Stipes more than 3 cm. long, with slight convex, dorsal curvature. The stipes are 1.0 mm. broad at the proximal extremity and become no broader distally. The rhabdosome appears to be thickened in the axillary portion. The axil is pointed, the angle of divergence being 320°. The sicula is blunt. The virgella and lateral spines are conspicuous. The thecae are 10 in 10 mm. and about 1 mm. or more in length, overlapping one-half to one-third of this length. They commonly open within an excavation occupying one-half the width of the stipe.

DICELLOGRAPTUS cf. SEXTANS Hall. Text-fig. 10.

Stipes straight or with slight curvature of ventral margin distally, 1 cm. long, 0.7 mm. wide distally and 0.5 mm. proximally, diverging at 295-305° from a blunt node-like sicula, which is large in some cases. Axil pointed; strong, lateral spines present in some specimens, though sometimes the sicular end is obscure. Thecae

12 in 10 mm., and up to 1.5 mm. long, overlapping not more than a quarter of their length, outer wall curved. Apertural excavations sometimes semi-circular, sometimes pouch-like, one-third to one-half the width of the stipe.



Text-fig. 8.—*Dicellograptus* cf. *complanatus* Lapworth, Port. 1, Par. of Mundoonen. No. S.533.

Text-fig. 9.—*Dicellograptus divaricatus* Hall var. *ripidus* Lapworth, Port. 61, Par. of Manton, No. S.581.

Text-fig. 10.—*Dicellograptus* cf. *sextans* Hall, Port. 152, Par. of Manton. No. S.554.

Text-fig. 11.—*Dicellograptus elegans* Carruthers, Port. 61, Par. of Manton. No. S.577.

Text-fig. 12.—*Dicellograptus* cf. *moftensis* Carruthers, Port. 152, Par. of Manton. No. S.560.

Text-fig. 13.—*Dicellograptus* cf. *pumilus* Lapworth, Port. 152, Par. of Manton. No. S.564.

Text-fig. 14.—*Dicellograptus* cf. *smithi* Ruedemann, Port. 152, Par. of Manton. No. S.565.

#### DICELLOGRAPTUS ELEGANS Carruthers. Text-fig. 11.

Stipes up to 3.5 cm. in length, showing strong and graceful curvature, diverging at large angles, 300–320°, from a faint sicula. The axil is square. Stipes 0.6 mm. wide proximally, which increases gradually to 0.8. Lateral spines observable conspicuously in some specimens. Thecae 11–9 in 10 mm. overlapping about a quarter of their length, which is about 1.5 mm., having a curved ventral wall and, in a profile view, an apertural excavation, which is about half the width of the stipe.

From a square axil nearly 1.5 mm. across, the stipes diverge but slightly for about 1 mm., then open with a graceful concave dorsal curvature until they are approximately 1 cm. apart, which distance is maintained for about 5 mm., when the stipes gently curve towards one another again, just meeting in unbroken specimens, at about 3.5 cm. perpendicularly from the axil in a large specimen. These specimens show the proximal double curvature "eminently characteristic of the species" and, like it, are ultimately convexly curved, and strongly resemble the plate of Carruthers' type specimen (Elles and Wood, 1904, Pl. xxiii, fig. 2a).

*DICELLOGRAPTUS* cf. *MOFFATENSIS* Carruthers. Text-fig. 12.

Stipes slender, 2 cm. in length, slightly curved, sub-parallel for 3 mm. proximally, then they diverge at  $320^\circ$ , converging slightly at the distal extremity. There is only a slight increase in width of the stipes to a maximum of 0.7 mm. Thecae 12 in 10 mm., overlapping one-quarter of their length of 1 mm. The free ventral wall is parallel to the dorsal margin of the stipe. Wide, semi-circular apertural excavations, occupying nearly half the width of the stipe. It is a small, fine form.

*DICELLOGRAPTUS* cf. *PUMILUS* Lapworth. Text-fig. 13.

The stipes are a little more than 1 cm. in length, with a uniform width of 5 mm. and diverge at about  $335^\circ$  from a very conspicuous sicula. A somewhat scalariform aspect of preservation probably makes the stipes appear narrower than they are. The axil is wide and the stipes curve very gently, first with a concave dorsal curvature, which is later reversed. The thecae are 12 or more in 10 mm., and overlap about half their length of 1 mm., with their outer walls slightly curved. The sicula, though very distinct, is broken. Figure No. 3c in Plate XXI of the Monograph of British Graptolites (Elles and Wood, 1904), where the angle of divergence is  $330^\circ$ , is closely comparable with this form, which has, however, finer stipes.

*DICELLOGRAPTUS* cf. *SMITHI* Ruedemann. Text-fig. 14.

Stipes up to 2 cm. long, of nearly uniform width, about 0.6 mm. wide. Thecae 10 in 10 mm. Stipes twisted near the sicula, which is noticeable, so that the ventral side of one stipe faces the dorsal side of the other, after diverging at an angle of  $330^\circ$  from a pointed axil. Subsequently the stipes converge and cross one another. The thecae are 1 mm. long and overlap one-quarter of their length. The forms compared with this species are precisely similar to specimens figured by Ruedemann (figs. 5 and 6, Pl. 19, Ruedemann, 1908).

## Family GLOSSOGRAPTIDAE Lapworth.

*RETIOGRAPTUS YASSENSIS*, n. sp. Plate xv, fig. 1.

Rhabdosome with sub-parallel margins, widening rapidly to a maximum breadth of 2 mm. without spines, 4 mm. with spines, which is maintained throughout. The maximum length observed is 3 cm. Test continuous over all but distal portion of rhabdosome, thickest in proximal portion, where it obscures the lists, but becoming more attenuated towards the distal end and apparently extremely attenuated or not present in the most distal thecae. In these thecae it is strengthened by lists into complete clathria with rhomboid meshes forming conspicuous ventral lattices. Sicula scarcely visible. Thecae alternate, proximal ones with their ventral and apertural lists produced into stout, arcuate spines which, however, become less conspicuous and almost disappear distally. Thecae 11-9 in 10 mm. The septal strand in the obverse aspect is well defined, straight and produced for a short distance beyond the rhabdosome.

*Remarks.*—*R. yassensis* resembles *R. pulcherrimus* Keble and Harris (Plate xv, fig. 2). Apart from any differences in the meshwork, however, it can be distinguished from Keble and Harris's species by its rapid widening in its proximal portion and its stouter arcuate spines. The septal strand in *R. yassensis* is also more conspicuous. *R. pulcherrimus* is a much longer form than *R. yassensis*.

Associated graptolites: *Diplograptus* (*Orthograptus*) *calcaratus* Lapw. var. *basilicus* Lapw., *D.* cf. *truncatus* Lapworth, *Climacograptus missilis* Keble and

Harris, *Cryptograptus tricornis* Carruthers, *Dicellograptus* cf. *complanatus* Lapworth, *D.* cf. *scrtans* Hall.

*Horizon*.—Upper Ordovician, Eastonian, high in that series.

*Locality*.—Portion 1, Parish of Mundoonen, 200 yards north of Morumbateman road junction (loc. 2).

Family MONOGRAPTIDAE Lapworth.

Genus MONOGRAPTUS Geinitz, restricted.

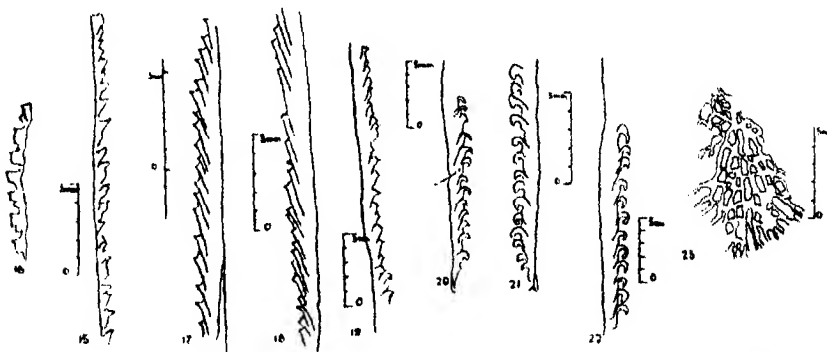
MONOGRAPTUS cf. *NILSONI* (Barrande). Text-figs. 15, 16.

Rhabdosome fragmentary, up to 2 cm. in length, slight convex dorsal curvature in the distal fragments which are found preserved in relief, proximal end not observed. Breadth 1 mm. Thecae 8 in 10 mm., show sigmoidal curvature, 2 mm. long and 0.4 mm. wide. Overlap very slight, angle of inclination  $20^\circ$ , apertural margin slightly concave, but generally at right angles to the direction of the rhabdosome. The thecae appear almost isolated when preserved in high relief (see Text-fig. 16), but this is probably due to the matrix not being completely removed.

Associates: *Nuclospira australis* McCoy, *Atrypa* sp., *Stropheodonta davidi* Mitchell.

MONOGRAPTUS cf. *TUMESCEUS* Wood. Text-figs. 17, 18.

Rhabdosome fragmentary, up to 3.5 cm. long (proximal end not observed), straight, maintaining a width of 1.7–2 cm. throughout. Sicula not seen. Thecae uniform in shape, becoming rather longer distally. Thecae 10–8 in 10 mm., long in proportion to their width, 2–3 mm. long, and 0.4–0.5 mm. broad. Overlap slightly more or slightly less than half. Thecae sometimes widening towards the apertural margin, which is concave in section, produced into a more or less distinct denticle. The angle of inclination is  $20$ – $25^\circ$ , which is the angle seen in figures of *M. tumescens* (figure 12a, Plate xxxvii, British Graptolites, Part VIII, Elles and



Text-fig. 15.—*Monograptus* cf. *nilsoni* (Barrande), Port. 34, Par. of Derringullen. No. S.134.

Text-fig. 16.—*Monograptus* cf. *nilsoni*. Reverse of Fig. 15.

Text-figs. 17, 18.—*Monograptus* cf. *tumescens* Wood, Port. 34, Par. of Derringullen. Nos. S.31, S.133.

Text-fig. 19.—*Monograptus* cf. *vomerinus* (Nicholson), Port. 34, Par. of Derringullen. No. S.9.

Text-figs. 20–22.—*Monograptus Flemingii* (Salter), Port. 34, Par. of Derringullen. Nos. S.333, S.73, S.334.

Text-fig. 23.—*Dictyonema* sp., Port. 34, Par. of Derringullen. No. S.312.

Wood, 1910). This angle of inclination prevents a comparison with *M. vulgaris* whose angle of inclination is 35-40°, which angle is shown in all figures of the species in the same Monograph (Elles and Wood, 1910).

Associate: *Stropheodonta davidi* Mitchell.

MONOGRAPTUS cf. VOMERINUS (Nicholson). Text-fig. 19.

Rhabdosome fragmentary, up to 3 cm. in length, fragments generally straight, breadth 1 mm. when preserved in high relief, 1.5 mm. when seen in cast, sicula not seen. Thecae 11 in 10 mm., slightly more than 1 mm. in length, about twice as long as wide, overlapping seldom more than a quarter of this length. The aspect of the thecae seen in relief differs from that seen in cast. In the latter case the thecal boundaries show an almost spiral curvature, and in the former a less pronounced ogee curvature.

Associates: *Atrypa* sp., *Stropheodonta davidi* Mitchell.

MONOGRAPTUS FLEMINGII (Salter). Pl. xv, figs. 4, 5; Text-figs. 20, 21, 22.

Rhabdosome incomplete, 2 cm. in length, straight or with slight dorsal curvature near the proximal end. Average width 1.7 mm. with a maximum of 2 mm. A width of 1.7 mm. is shown by the specimens figured here, and at an equivalent distance from the proximal extremity, viz., the fourteenth theca, in figures of *M. flemingii* in the Monograph of British Graptolites (Fig. 5d, Pl. xlii, Elles and Wood, 1912). A sicula is not often preserved, but, when seen, has a length of 1.6 mm. Thecae 12-9 in 10 mm. They show ogee curvature and become narrower towards their apertural extremities. They are about 2 mm. long, and up to 7 times as long as wide. Up to one-third of the theca itself may be involved in a hook, which occupies less than half the breadth of the rhabdosome, usually about two-fifths, the thecal overlap is from one-quarter to two-thirds of the total length. The hooks may be called beak-like rather than claw-like, but the mode of preservation and angle from which the specimen is examined cause a difference in the appearance of the ventral margin, so that the hooks are not perceptible at all from one angle. The inter-theal line is strongly marked. The fragmentary state in which the graptolites are found is characteristic of *M. flemingii*, while their straightness and stiffness preclude their reference to *M. riccartonensis* or *M. uncinatus* var. *orbatus*, which are characterized by a "limp, broken-backed appearance" (Elles and Wood, 1912).

Associates: *Nucleospira australis* McCoy, *Stropheodonta davidi* Mitchell, *Atrypa* sp.

Acknowledgements.

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## EXPLANATION OF PLATE XV.

Fig. 1.—*Retiograptus yassensis*, n. sp. Complete rhabdosome obverse aspect. Port. 1, Par. of Mundoonen. No. S.501.

Fig. 2.—*Retiograptus pulcherrimus* Keble and Harris. Proximal portion. Yarra Track, Victoria. No. 26691, Nat. Mus. Melb.

Fig. 3.—*Climacograptus tubuliferous* Lapworth, Port. 61, Par. of Manton, No. S.591.

Figs. 4, 5.—*Monograptus Flemingii* (Salter), Port. 34, Par. of Derringullen. Nos. S.333, S.336.

(Where not otherwise stated, specimens are in the collection of one of the authors—K.M.S.)

# THE ECOLOGY OF THE CENTRAL COASTAL AREA OF NEW SOUTH WALES. I.

THE ENVIRONMENT AND GENERAL FEATURES OF THE VEGETATION.

By LILMA M. PIDGEON, M.Sc., Linnean Macleay Fellow in Botany.

(Plates xvi-xvii; six Text-figures.)

[Read 24th November, 1937.]

The area considered in this series of papers is the central coastal plateau region east of the main divide extending to the edge of the Hunter Valley in the north, to Cox's River in the west and to the Lower Shoalhaven Valley in the south. It includes the County of Cumberland, and the adjoining portions of the Counties of Northumberland, Hunter, Cook and Camden (Long. 150-151.5, Lat. 33-35 approx.).

Two plant-formations occur in this area: Eucalyptus forest and sub-tropical rain-forest. The endemic Australian and Indo-Malayan floristic elements correspond respectively to these formations (Malden, 1914). Eucalyptus forest is the dominant formation not only of the central coast but of the whole coastal area and adjacent highlands<sup>1</sup> of New South Wales. It shows several important phases which are due to the variation in soils, climatic factors and physiographic habitats.

Rain-forest is limited to the coastal belt where there is a high rainfall; there it occurs in scattered patches on good soil, usually in areas sheltered from winds and extreme insolation.

In this series of papers a description is given of the structure and composition of these coastal Eucalyptus forests, especially those typical of the two characteristic geological formations of the area: Hawkesbury Sandstone and Wianamatta Shale. An attempt is made to classify the Eucalyptus forests on the basis of associations (Clements, 1916, 1936) within the formation. The successional phases of the sandstone vegetation are also discussed.

The Mt. Wilson forests, which form part of the Eucalyptus forest formation occurring in this area, have been described in detail by Petrie (1925), and McLuckie and Petrie (1926); Davis (1936) has outlined the forest communities occurring on a portion of the Illawarra (South Coast). No other detailed forest ecology has been done in this area, but reference must be made to the general accounts by Robertson (1926) and Osborn (1932). A number of general floristic accounts of the sandstone flora, chiefly in the Sydney District, have also been published. Reference will be made to these in later publications.

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<sup>1</sup> On the western slopes of the Dividing Range, this formation gives place to a more open type of vegetation known as savannah woodland.



## THE ENVIRONMENT.

*Geology.*<sup>2</sup> (See Text-fig. 1.)

With the exception of some volcanic rocks, chiefly basalts, and some deposits of river alluvium and wind-blown sand, the geological formations occurring in the area are sedimentary. The sequence of the sedimentary series is as follows:

Triassic	{	Wianamatta Shales.
		Hawkesbury Sandstones.
		Narrabeen Shales and Sandstones.
Permian	{	Upper Coal Measures
		(Newcastle-Bulli-Lithgow).
		Upper Marine Series.

Centring about Sydney the Permian rocks are in the form of a great basin, whose rim appears at the surface on the north, west and south of the area, the eastern rim being submerged by the ocean (Text-fig. 1). The individual formations of the Triassic System lie conformably above the Permian Basin. These sedimentary strata are generally horizontal. Most of the beds are thickest in the vicinity of Sydney or along the adjacent coastline.

The lower beds of the Upper Marine Series consist chiefly of siliceous conglomerates and coarse sandstones, with a small amount of shaly and fine-grained sandstones. The upper beds of this series comprise calcareous shales, sandstones and mudstones with tuffaceous material and lava flows which are particularly prominent in the coastal districts in the south of the area (Illawarra). The Upper Marine Series attains a thickness of several thousand feet in the south but becomes thinner at its western rim.

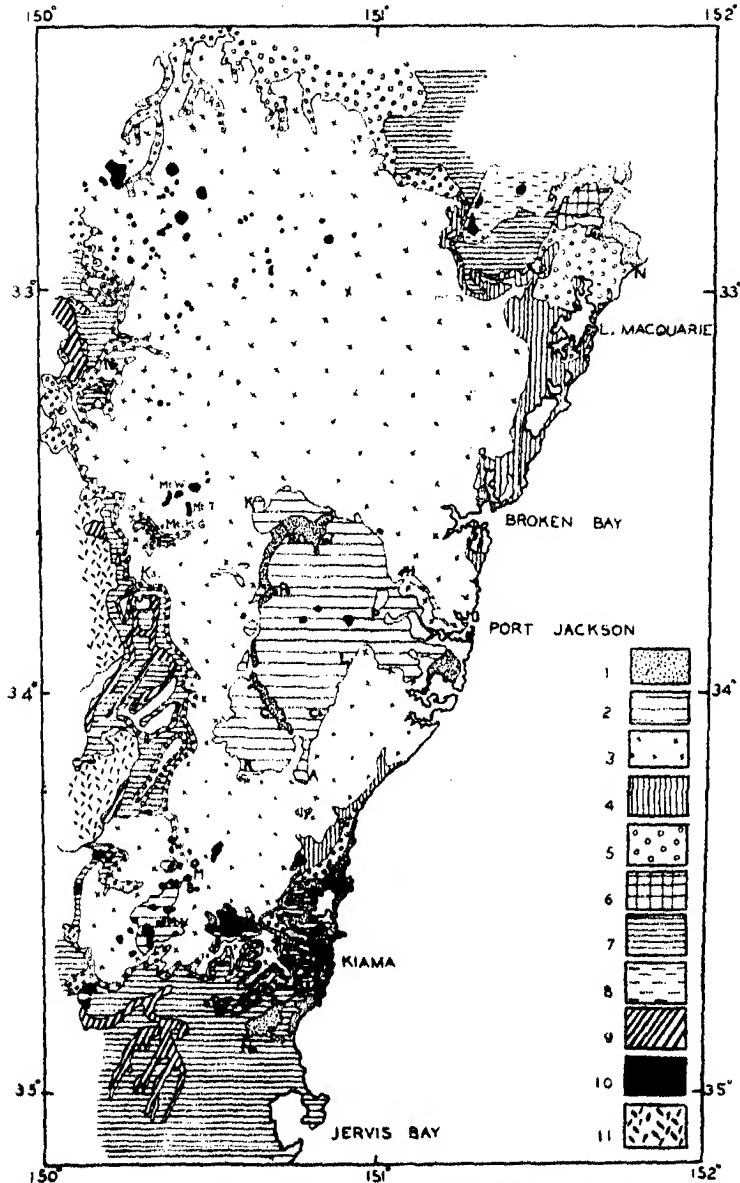
The Upper Coal Measures include sandstones, conglomerates, shales and cherty tufts with coal seams. On the coastline (at Bulli) the coal-measures have a thickness of about 1,000 feet, which decreases to 400 feet in the west (Mt. Victoria and Lithgow).

Sandstones compose the greater part of the Narrabeen Series where it outcrops on its western rim (Blue Mts.), but along the coast shales and sandy shales are also important. The maximum thickness of the Narrabeen Beds on the coast is 1,740 feet, but this decreases to 300 feet in the west (Mt. Victoria). A very constant feature is the occurrence of tuffaceous chocolate shales, which form two conspicuous bands near the top of the series. They are often more than 100 feet

<sup>2</sup> In compiling these geological notes the following articles have been consulted: Willan (1923), Woolnough (1927), Handbook A.N.Z.A.A.S. (1932).

5. Upper Coal Measures	{	Permian.
6. Middle Coal Measures		
7. Upper Marine Series		
8. Lower Marine Series		
9. Quartzites, sandstones, shales, limestone, etc.	{	Devonian.
<i>Igneous.</i>		
10. Mainly basalts.		Tertiary (principally).
11. Mainly granites.		Permian to Pre-Cambrian.

Towns referred to are: A, Appin; B, Berry; Bo, Bowral; Bu, Bulli; C, Camden; Ca, Campbelltown; G, Gosford; H, Hornsby; K, Kurrajong; Ka, Katoomba; L, Liverpool; M, Mittagong; MV, Moss Vale; N, Newcastle; Ne, Newnes; No, Nowra; P, Parramatta; Pe, Penrith; Pl, Pilton; R, Richmond; W, Windsor.—Mt. W., Mt. Wilson; Mt. T., Mt. Tomah; Mt. K.G., Mt. King George.



Text-fig. 1.—Geological map of the central coastal area, adapted from the Geological Map of N.S.W., Dept. of Mines, 1914. Scale, 1" = 32 miles.

*Sedimentary.*

- |   |                                   |
|---|-----------------------------------|
| 1. Alluvial deposits and wind-blown sand. | Recent, Pleistocene and Tertiary. |
| 2. Wianamatta Series                      | } Triassic.                       |
| 3. Hawkesbury Sandstones                  |                                   |
| 4. Narrabeen Series                       |                                   |

thick on the coast but diminish towards the west, although still conspicuous in the cliffs of the Blue Mts.

The Hawkesbury Series, which is the most extensive, consists chiefly of siliceous sandstone with a few small lenticular beds of shale. The sandstone occurs in the form of massive jointed bands which weather into blocks. Bands of grit and conglomerate which occur in the sandstone become increasingly more important to the west. The Hawkesbury Sandstones attain a depth of 1,100 feet at Sydney, but in the west at Mt. Victoria the thickness is only 100 feet. Here, the thinning out of the beds has been accentuated by erosion.

The Wianamatta Series has been divided into two stages. The lower consists almost entirely of laminated shale which is carbonaceous and ferruginous near the base. Beds of a very calcareous sandstone form the upper stage. A maximum thickness of 1,000 feet is attained in the Camden district. These shales are easily weathered and have been eroded over a large area.

Some Pleistocene and recent river alluvials are found on the Sydney and coastal plains. There are also some fairly large areas of blown sand, derived chiefly from Hawkesbury Sandstones, which form dunes in the coastal areas.

In the vicinity of Sydney igneous rocks occur scattered as innumerable small intrusions, usually in the form of dykes. Several volcanic necks also occur. Larger intrusions occur at Prospect, Mt. Jellore (dolerite) and Mt. Gibraltar (syenite). Remnants of basalt flows which were once very extensive cap several physiographic residuals in the Blue Mts. and occur on the uplands in the vicinity of Bowral, Moss Vale, etc. All these igneous rocks are relics of the Pliocene volcanic epoch.

More extensive and important are the flows of trachy-andesites and trachy-basalts which are interbedded with the shales and sandstones of the Upper Marine Series. Other evidence of volcanic activity at this period is seen in the presence of basic tuffs and tuff mudstones in the same series.

#### *Physiography.*<sup>1</sup> (See Text-fig. 2.)

##### (1) General.

To the north, south and west of Sydney is a deeply dissected plateau region composed chiefly of Hawkesbury Sandstones. This encircles a central gently undulating low-lying area, the Sydney Plains, in which the underlying rocks are Wianamatta Shales. These plains are connected to the coast by an E-W strip of land which interrupts a precipitous coastline of sandstone headlands alternating with narrow beaches. This type of coastline, broken in several places by drowned river-valleys, characterizes the central part of the coast. To the north and south, a narrow undulating coastal plain gradually widens as the sandstone scarp recedes from the coastline.

The general physiographic features of the area are the result of a differential uplift in the Kosciusko Epoch<sup>2</sup> which converted a late Tertiary peneplain into a plateau with a general upward slope on the west, but with two central depressions or troughs, due to lagging during the uplift or subsequent sagging. The present alignment of the coast is probably due to faulting and foundering of a coastal strip at a period later than that of the main uplift. This subsidence of the coast to the extent of 150-200 feet resulted in the drowning of several large river valleys.

<sup>1</sup> This brief account of the physiography of the area is drawn largely from the A.N.Z.A.A.S. Handbook (1932).

<sup>2</sup> About the close of the Pliocene Period.

This was followed by a more recent emergence of 15 feet. Erosion by undercutting of the sandstone was a further factor in determining the coastal physiography.

Some diversity in altitude occurs over the area (see Text-figs. 2, 3). The Sydney Plains, which have an average elevation of 100-200 feet, are bounded to the west by a steep monoclinical fold forming the edge of the Blue Mts. Plateau which rises from this scarp more gradually to a level of 3,500 feet on its western margin. On the west, the Blue Mts. Plateau is separated by the wide valley of Cox's River from the Jenolan Plateau which rises to over 4,000 feet.

On the north and south of Sydney, the land increases in elevation gradually. To the north, the "Hornsby Plateau" rises to an average elevation of 600-700 feet and is then interrupted by the steep foreshores of the drowned valley of the Hawkesbury River. North of this it gradually attains an elevation of 1,700-1,900 feet, terminating as a scarp overlooking the southern edge of the Hunter Valley. South of Sydney the coastal plateau, sometimes referred to as the Nepean Ramp, rises more gradually and increases in elevation from 500 feet to a maximum of 2,000 feet at Robertson in the south and Mittagong and Moss Vale in the south-west. The plateau in these districts is conveniently referred to as the Robertson and Moss Vale-Mittagong Plateaux. The southern boundary of this sandstone plateau is the northern edge of the Lower Shoalhaven Valley.

The areas to the north and south of the Blue Mts. attain an average elevation of 2,500 feet, and may be referred to as the Colo and Wollondilly regions. These plateau areas link up with the northern part of the Hornsby Plateau and the southern section of the Nepean Ramp to form a continuous semicircular plateau extending from the Hunter Valley west of the Sydney Plains to the Lower Shoalhaven.

It is generally accepted that the rivers of the coastal area were either brought into existence or rejuvenated from a mature or senile condition by the uplift. The stream-patterns in the central coastal area indicate a complex history which cannot be discussed here (see Handbook, 1932).

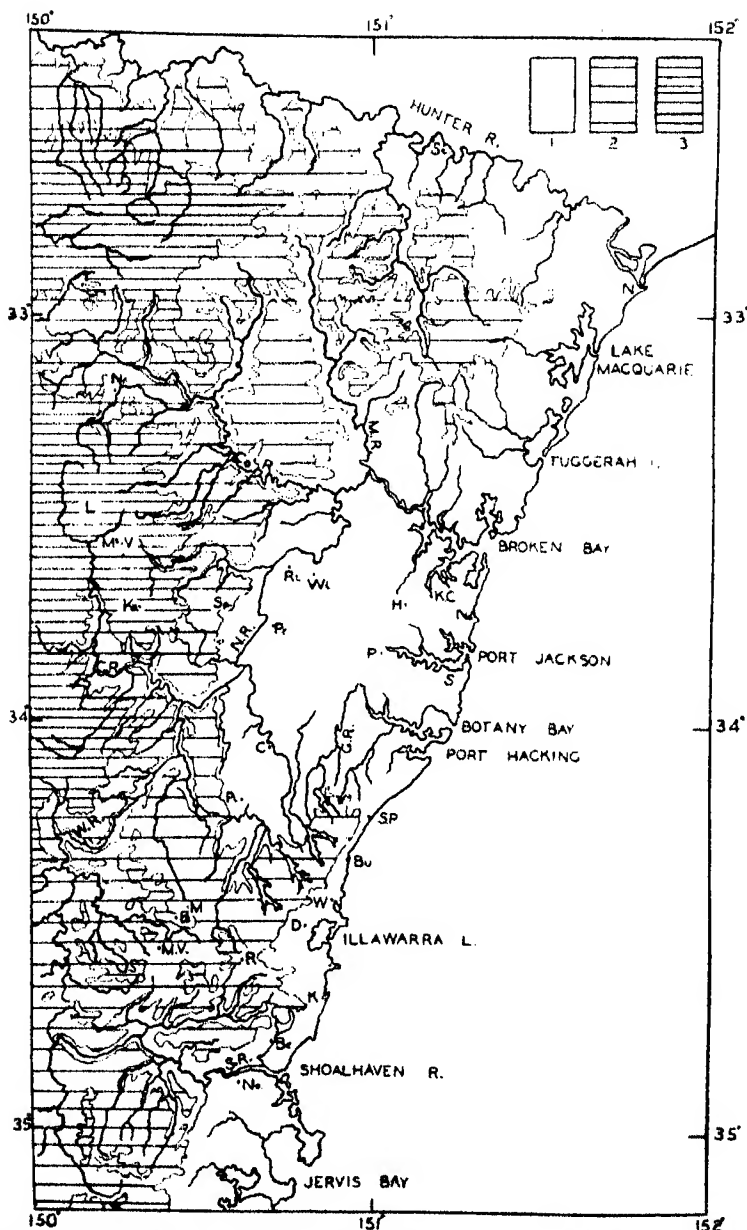
The Nepean is the largest river (see Text-fig. 2). It rises in the Nepean Ramp and flows in a northerly direction, but changes its course abruptly to the east and joins the sea as the Hawkesbury River. Several tributaries of the Nepean drain the Nepean Ramp. These are the Cataract, Cordeaux and Avon Rivers, whose steep gorges have been dammed. Other important tributaries of the Nepean are the Wollondilly and Cox's Rivers, which join the Nepean as the Warragamba River, and the Grose, Colo and Macdonald Rivers.

There are no rivers of any magnitude on the coast between the Hawkesbury and Shoalhaven. The most important of the smaller streams are the Port Hacking and George's Rivers. Tributaries of the Hawkesbury, such as the Berowra, Cowan, Mangrove and Mooney Mooney Creeks are of local importance only.

## (2) Physiographical Regions.

### (a) *The Sydney Plains.*

The plains are gently undulating, with many hills up to 300 feet. They are formed by two low-lying regions or depressions; one is a submeridional depression extending from about Windsor to Picton, bounded on the west by the monocline of the Blue Mts. (Pl. xvi, fig. 1), and on the east warping into the low coastal plateau. The other is an east-west trough which connects the submeridional depression to the coast between the drowned valleys of Port Jackson and Botany Bay, thus dividing the coastal uplands into the Hornsby Plateau and Nepean Ramp.



Text-fig. 2.—Relief map of the central coastal area, adapted from the 1:1,000,000 map. 1, below 1,000 feet; 2, 1,000-2,300 feet; 3, above 2,300 feet.

Towns referred to are: B, Bowral; Be, Berry; Bu, Bulli; C, Camden; D, Dapto; H, Hornsby; K, Kiama; Ka, Katoomba; K.C., Kuring-gai Chase; L, Lithgow; M, Mittagong; M.V., Moss Vale; Mt. V., Mt. Victoria; N, Newcastle; Na, Narrabeen; Ne, Newnes; No, Nowra; P, Parramatta; Pe, Penrith; Pl, Picton; R, Robertson; Ri, Richmond; S, Sydney; Si, Singleton; Sp, Springwood; SP, Stanwell Park; W, Wollongong; Wi, Windsor.

Rivers referred to are C.R., Cox's River; Co.R., Colo R.; G.R., George's R.; M.R., Macdonald R.; N.R., Nepean R.; S.R., Shoalhaven R.; W.R., Wollondilly R.

The Wianamatta Shales are co-extensive with the Sydney Plains, the physiography of this area having enabled their preservation. Shallow shale outliers occurring on parts of the sandstone uplands (see Text-fig. 1) indicate that a more extensive distribution obtained before the uplift and that subsequent restriction of these shales is due to erosion. The beds of the upper stage of the Wianamatta Series are more resistant than the lower soft shales and persist as hills and ridges, the most outstanding of which is Razorback Ridge, near Camden.

Alluvial deposits occur along the Nepean and Hawkesbury Rivers within the Sydney Plains. These alluvials have probably been derived from the adjoining sandstone uplands.

(b) *The Sandstone Plateau.*

The horizontal bedding and resistant nature of the Hawkesbury sandstones are responsible for the typical physiographic and scenic characteristics of the plateaux, such as flat-topped hills and divides, and steep gullies and gorges.

There is evidence of an uplifted peneplain in the generally even skyline. This is broken in the west by the pre-Pliocene peneplain residuals of the basalt-capped Mt. Hay, Mt. King George, Mt. Tomah and Mt. Wilson in the Blue Mts., and in the south by the igneous intrusions of Mts. Jellore and Gibraltar near Bowral, which are also more resistant to erosion.

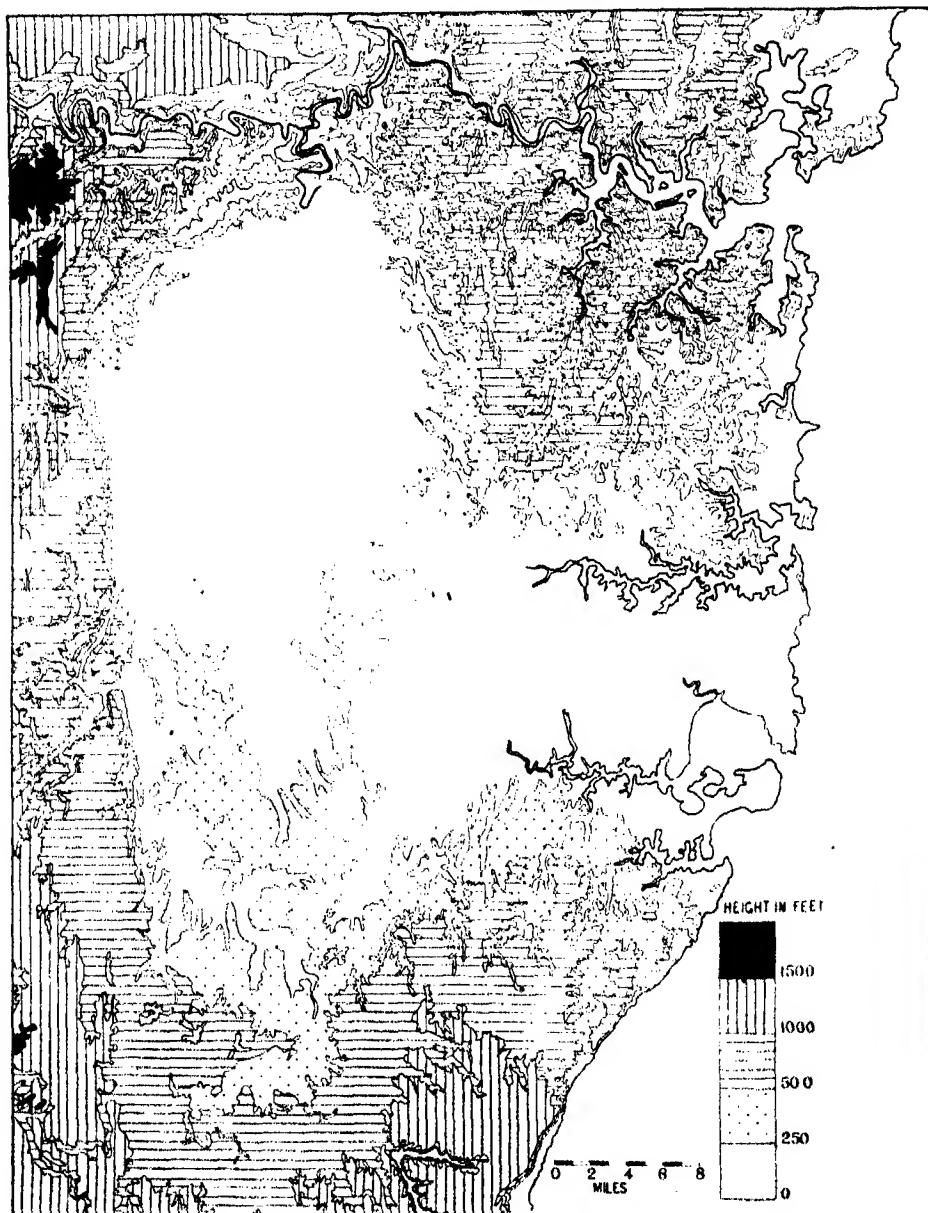
In the Blue Mts. deep gorges and canyons (Pl. xvi, fig. 2) dissect the plateau, the remnants of which form flat divides. Hawkesbury sandstone forms the surface of the plateau and, in the eastern section, extends to the bottom of the gorges. In the central and western sections, the rivers have cut through the sandstones of the Hawkesbury and Narrabeen Series to the soft shales of the Coal Measures. By erosion of the latter, and undercutting the upper sandstone layers, a type of canyon has been formed which is characteristic of the Blue Mts. Notable canyons are those of Cox's River and its tributaries, and the Grose River. In these canyons, whose walls are 3,000 feet high, the Hawkesbury and Narrabeen Beds constitute sheer cliffs, whilst steep talus slopes and wide level floors are formed by coal measures.

One peculiar physiographic feature in the Blue Mts. is that the streams not uncommonly occupy valleys which are too large for them, and in which erosion is now not active. This is satisfactorily explained only by an assumed lowering of the rainfall since Pleistocene time.

The Colo and Wollondilly plateau regions are characterized by juvenile gorges. Little is known of this uninhabited country, owing to its extremely rugged nature.

The northern upland area bordering the coast, the Hornsby Plateau (Pl. xvi, figs. 4, 3), is for the most part dissected by deep juvenile gorges separated by narrow divides. Owing to erosion, the Wianamatta Shales in the Hornsby Plateau are now restricted to the flat divide separating the deep valleys of Lane Cove River and Middle Harbour, and to a similar divide to the west which links up with the shales of the Sydney Plains. The Hawkesbury Sandstones are several hundred feet thick in this plateau, so that the Narrabeen Shales are exposed only in the deepest gorges.

The southern upland area, the Nepean Ramp, is not so dissected as the Hornsby Plateau. Broad, shallow, and sometimes swampy upland valleys are typical of the headwaters of the Cataract, Cordeaux and Avon rivers beyond the limits of rejuvenation. The Robertson Plateau, which is the southern extension of the Nepean Ramp, is a typical peneplain fringed by waterfalls and deep gullies. The Shoalhaven and Kangaroo Valleys, at the southern limit of the area, are typical canyons.



Text-fig. 3.—Relief map of the Sydney Plains and surrounding plateaux, reproduced by courtesy of Professor J. Macdonald Holmes of the Geography Dept., Sydney University. The estuaries shown from north to south are: Broken Bay, Port Jackson, Botany Bay and Port Hacking.

Although most of this southern plateau area is composed of sandstone, there is a fairly extensive capping of Wianamatta Shale in the vicinity of Moss Vale and Mittagong. In the same locality there are a number of remnants of basalt flows, particularly evident at Bowral, Moss Vale and Robertson.

(c) *The Coastal Plains.*

From Sydney, south to Stanwell Park and north almost to Broken Bay, the Narrabeen Series is below sea-level, so that Hawkesbury Sandstone cliffs extend to the sea. North and south of this area the Narrabeen Series outcrops, and at a further distance north and south, the Coal Measures also appear above sea-level. Where these softer strata outcrop, a coastal plain has been formed by erosion and subsequent undercutting of the overlying more resistant Hawkesbury Sandstone (Pl. xvi, fig. 6). This coastal plain widens and the sandstone scarp gradually recedes inland to the north and south as the sandstone capping of the plateau becomes thinner, and as progressively greater amounts of the underlying strata rise to the surface. This has enabled the coastal streams to erode farther back from the coast, and also to develop small flood-plains.

The central part of the coast-line, from Stanwell Park in the south to Broken Bay in the north, consists of short sand beaches alternating with headlands (Pl. xvi, fig. 5). The drowned river-valleys which interrupt this coastline are Port Hacking, Botany Bay, Port Jackson and Broken Bay. Of these, only the foreshores of Botany Bay and the southern shore of Port Jackson are low-lying. The estuaries of Broken Bay and Port Jackson extend far into the plateau, but all come under tidal influence for some distance up their estuaries.

South of Port Hacking the sandstone headlands are several hundred feet high and the beaches are very narrow (Pl. xvi, fig. 5). North of Port Jackson the sand beaches are much larger and lagoons usually occur behind them. There is a local development of a narrow coastal plain at Narrabeen and Newport, where the Narrabeen shales are exposed above sea-level. The irregular sandstone scarp of the Hornsby Plateau which skirts the coastline from Port Jackson to Broken Bay is about 400 feet high.

The coastal plain south of Stanwell Park, which is known as the Illawarra (Pl. xvi, fig. 7), and that north of Broken Bay gradually widen to approximately 10 miles in the vicinity of the Shoalhaven River in the south and to 15 miles at Lake Macquarie in the north. At Kiama, in the Illawarra, the plain is interrupted by the volcanic Saddleback Range which descends to the sea in very steep hills. The coastline bordering these plains also consists of headlands alternating here with long beaches, behind many of which are lagoons. Of these the most important are Lake Illawarra and Lake Macquarie.

North of Broken Bay, the Narrabeen Beds are responsible for the coastal plain and hill formations except in the vicinity of Lake Macquarie where the Coal Measures appear (see Text-fig. 1). On the other hand, the Illawarra is composed mainly of Coal Measures, Upper Marine Series including volcanic material, and river alluvials. Narrabeen Shales form the lower slopes of the northern section of the Illawarra scarp.

*Soils.*

Only a general survey of soil types is attempted here; later papers contain detailed data. In the following, field observations have been supplemented by tables of soil analyses, etc., from Jensen (1914).

In the central coastal area the soils are derived chiefly from the underlying formation *in situ*, small areas only being composed of re-distributed alluvial or wind-blown soil.



The three most extensive geological formations in this area weather to soils of very different texture; the Hawkesbury Sandstones yield sandy soils, the Wianamatta Shales heavy clay-loams, and the Narrabeen Shales rich loams. The volcanic soils are rich but very restricted.

For convenience, the soils are discussed under the following headings: sandstone, shale, igneous, alluvial and lateritic soils.

#### (1) Sandstone Soils.

According to the nature of the cementing material of the sandstone, the soils vary from poor sandy soils to fairly rich loams.

Siliceous sandstones, with aluminous or ferriferous clay as the cementing material, yield light-coloured sandy loams, poor in mineral plant food (see Table 1, lines 1 and 2). Such soils are derived from the Hawkesbury Sandstones, the conglomerates and sandstones of the lower beds of the Upper Marine Series, occurring in the vicinity of Nowra and Jervis Bay, and the sandstone and conglomerate beds in the Newcastle Coal Measures, in the north of the area (see Text-fig. 1). They are characterized by a low water-retaining capacity, and high capillarity. Where the sub-drainage and run-off are good, they are fairly warm soils, but where the ground-water level is high, the soils are cold and sour. These siliceous sandstone soils are considerably improved by the addition of humus, the percentage of which is frequently high on sheltered slopes and in gullies.

In contrast to the shallow soils derived from the sandstones and conglomerates of the lower beds of the Upper Marine Series, the shaly and fine-grained sandstones in the same beds yield a deeper and more loamy soil, with a clayey subsoil. In the Nowra district the latter soil type occurs in patches in the former poorer sandstone soils (see Table 1, lines 1 and 3).

Where the cementing material is calcareous, the sandstone yields a much better soil-type of moderately dark-coloured loam. Soil derived from tuffaceous sandstones in which lime-felspar partly takes the place of quartz, may be included in this class. Shales and mudstones of a similar composition, which are typical of the Permian series in the Illawarra (Bulli Coal Measures and upper beds of Upper Marine Series) yield a similar soil. Jensen has shown that these loams have a much better proportion of mineral plant-food than the siliceous sandstone soils, and frequently contain quite a high percentage of lime (see Table 1, lines 4-7).

Table No. 1 (compiled from Jensen) gives the averages of a number of analyses of soils described above. In all the tables the figures represent percentages, with the exception of capillarity, which is expressed in inches.

#### (2) Shale Soils.

The Wianamatta Shales weather to heavy loams or clays, about 8 or 9 inches in depth, with a clayey sub-soil which varies in depth according to the chemical nature of the underlying shales. The basic (ferriferous and calcareous) shales frequently have a dark red-brown coloured friable clay subsoil, about 3 feet in depth. Most of the shales are acid (70% silica) and weather very slowly, so that the sub-soil, which is of stiff yellow clay, averages not much more than 10 inches. These soils are hard and stiff and become saturated in wet weather owing to their impervious nature and lack of sub-drainage. During dry weather they become desiccated and cracked, so that the rise of water by capillarity is prevented. The physiographic and climatic factors increase the physical disadvantages of these soils; the low-lying nature of the country frequently accentuates the lack of

TABLE 1.

Locality.	Geological Series.	Colour.	Water Capacity.	Capillarity.	Clay.	Mobility.	Volatile.	Nitrogen.	Lime.	Potash.	Phosphoric Acid.
Siliceous Sandstones	Norwa .. .. .	Light ..	30.0	6.0	35.0	3.31	4.37	0.079	0.044	0.036	0.039
	County Cumberland ..	Light ..	37.9	9.2	18.8	—	7.22	0.133	0.106	0.066	0.137
	Norwa .. .. .	Light ..	39.0	4.0	53.0	3.7	6.42	0.147	0.055	0.057	0.036
	Ilawarra .. .. .	Moderately dark ..	—	—	—	4.2	10.20	0.185	0.353	0.127	0.165
Calcareous and Tuff Sandstones.	Wollongong, Mt. Kiera slopes..	Light brown	48.0	5.0	79.7	5.36	14.43	0.322	0.582	0.213	0.232
	Ilawarra .. .. .	Light brown	48.0	5.0	79.7	5.36	14.43	0.322	0.582	0.213	0.232
	Near Mt. Kembla slopes ..	Light grey ..	50.0	8.5	51.0	2.02	6.05	0.126	0.305	0.093	0.182
	Unanderre Flats ..	Dark grey ..	39.0	6.5	85.2	3.95	11.52	0.112	0.510	0.140	0.216

natural sub-drainage, while during drought periods, which are not infrequent, the soil is badly cracked and dried.

The Wianamatta Shale soils are poor in mineral plant-food, as is indicated in the following table, which gives their average analysis calculated from ten soils:

TABLE 2.

Locality.	Water Capacity.	Capillarity.	Clay.	Volatile.	Nitrogen.	Lime.	Potash.	Phosphoric Acid.
Sydney Plains	52.5	5.2	67.7	7.62	0.140	0.136	0.133	0.096

The calcareous ostracod sandstones and shales in the upper beds of the Wianamatta Series yield rich red and chocolate friable clayey soils, containing about 0.5% of lime. These soils occur on the eastern slopes of the Blue Mts. in the vicinity of Kurrajong.

The Narrabeen Shales, which contain volcanic detritus, and the Upper Marine tuff shales in the Kiama-Nowra district, yield dark, rich, deep and fine-textured loams.

### (3) Igneous Soils.

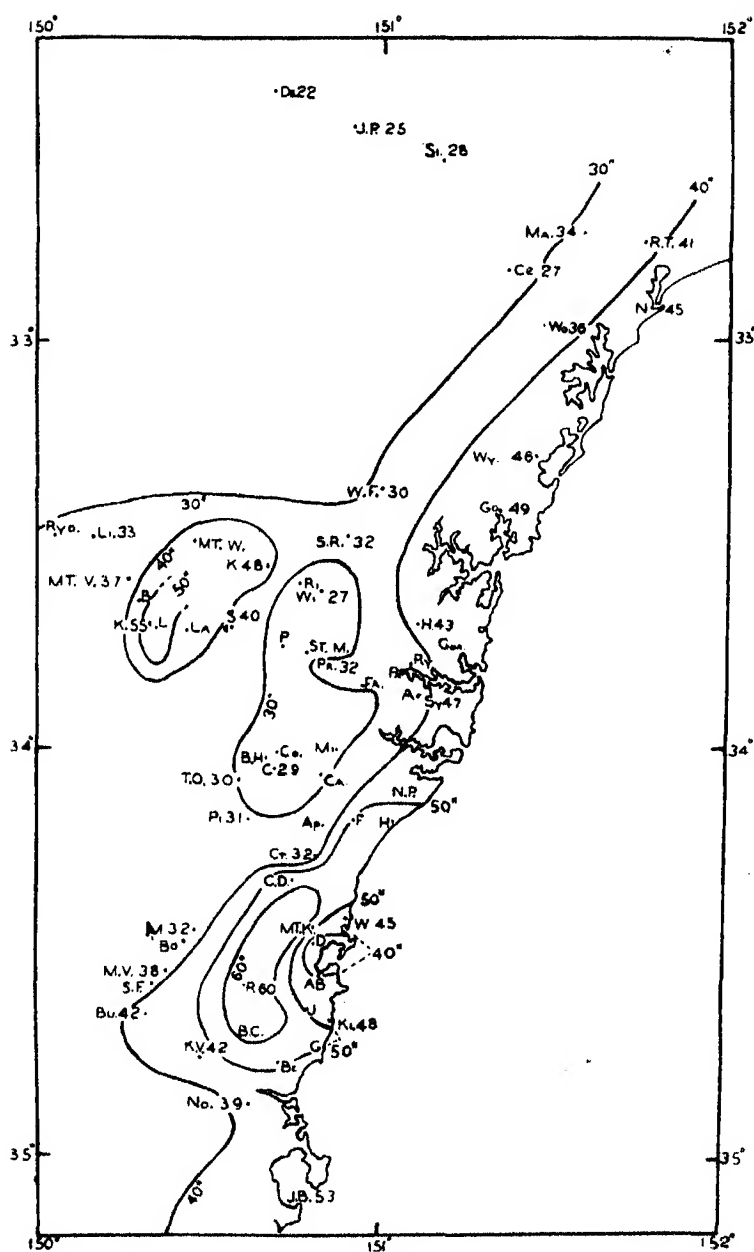
Interbedded with the Illawarra Permian sandstones and mudstones are sills of basalt and beds of tuff which yield very fertile loamy soils, as indicated by Table 3.

The Tertiary trachytes and basalts at Bowral, Moss Vale, etc., yield fairly rich loams. The basalt soils of Mts. Tomah, Hay, etc., are rich in potash, phosphoric acid, magnesia, and lime.

The basalt soils of the Sydney district are of little importance from the

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Stations plotted, showing mean annual rainfall (inches) of each, followed by number of years record (in parenthesis): A, Ashfield, 35.4 (35); Ap, Appin, 35.7 (30); AB, Albion Park, 41.1 (41); B, Blackheath, 42.2 (38); Be, Berry, 56.5 (more than 15); Bo, Bowral, 36.7 (51); Bu, Bundanoon, 42.3 (35); B.H., Brownlow Hill, 27.7 (54); BC, Brogers Creek, 76.9 (39); C, Camden, 29.8 (52); Ce, Cessnock, 27.7 (30); Co, Cobbity, 29 (48); C.D., Cordeaux Dam, 59.3 (64); Ca, Campbelltown, 28.4 (54); Cr, Cataract, 32.7 (53); D, Dapto, 39.6 (24); De, Denman, 22.1 (53); F, Darkes Forest, 50.5 (39); Fa, Fairfield, 32 (6); G, Gerringong, 50.3 (41); Go, Gosford, 49.7 (53); Gor., Gordon, 43 (28); H, Helensburgh, 57.3 (47); J, Jamberoo, 49.3 (more than 15); J.P., Jerry's Plains, 25.1 (49); J.B., Jervis Bay, 53.2 (69); K, Kurrajong, 48.7 (67); Ki, Kiama, 48.5 (38); K.V., Kangaroo Valley, 42.6 (14); L, Leura, 52.4 (23); La, Lawson, 48.6 (41); Ll, Lithgow, 33.3 (46); M, Mittagong, 32.7 (34); Mi, Minto, 29.8 (47); M.V., Moss Vale, 38.8 (63); Ma, Maitland, 34.0 (68); MT. K., Mt. Kembla, 60.4 (21); MT. W., Mt. Wilson, 49.3 (more than 15); MT. V., Mt. Victoria, 37.5 (63); N, Newcastle, 45.5 (71); No, Nowra, 39.7 (38); N.P., National Park, 43.3 (26); Pr, Prospect, 32.9 (43); P, Penrith, 29.1 (39); Pa, Parramatta, 35.6 (69); Pi, Picton, 30.9 (56); R, Robertson, 60.5 (46); Ri, Richmond, 29.3 (55); Ry, Ryde, 35.1 (35); Ryd, Rydal, 31.3 (21); R.T., Raymond Terrace, 41.2 (42); S, Springwood, 39.9 (48); Sl, Singleton, 28.1 (53); St. M., St. Marys, 27.6 (39); Sy, Sydney, 47.3 (77); S.F., Sutton Forest, 35.5 (32); T.O., The Oaks, 30.3 (24); S.R., Sackville Reach, 32 (27); W, Wollongong, 45.7 (61); Wo, Wollong, 36.7 (45); Wy, Wyong, 46.1 (45); Wl, Windsor, 27.4 (38); W.F., Wiseman's Ferry, 30.6 (18).



Text-fig. 4.—Isohyet map constructed from data supplied by Mr. Mares of the Sydney Weather Bureau and Mr. W. S. Watt, Commonwealth Meteorologist. 30, 40, 50 and 60 inch isohyets shown.

ecological viewpoint owing to their small extent. The numerous dykes and pipes weather much more rapidly than the sandstone or shale, so that they form depressions in the surface. These basalt soils are red in colour and much richer than the shale or sandstone soils. The Prospect dolerite yields a deep chocolate-coloured clayey soil of friable texture due to the high percentage of lime (1-1.5%).

TABLE 3.

Locality.	Geological Type.	Texture.	H <sub>2</sub> O Capacity.	Capillarity.	Clay.	Moisture.	Volatile.	Nitrogen.	Lime.	Potash.	Phosphoric Acid.
Kiama hillside.	Bombabasal.	Heavy loam.	35	6	68.0	8.3	24.65	0.651	0.602	0.234	0.074
Kiama hillside.	Jamberoo tuffs.	Clay	56	7	75.7	5.3	12.85	0.238	0.384	0.157	0.137

#### (4) Alluvial Soils.

The alluvial soils in the Nepean-Hawkesbury area have probably been derived from the adjacent Hawkesbury Sandstone country; they yield similar siliceous sandy loams.

The alluvials of the southern Illawarra are much better soils, since they are of very mixed origin. They vary from heavy to light loams.

#### (5) Lateritic Soils.

On the Hornsby Plateau, and parts of the Nepean Ramp and Blue Mts., shallow patches of a somewhat lateritic soil-type not infrequently occur on the surface of soils derived from Wianamatta Shales and from Hawkesbury Sandstones. The lateritic nodules are thought to have been formed in the subsoil of the Tertiary peneplain and, by erosion of the upper soil, masses of these "ironstone" nodules, either non-coherent or cemented, have been left on the surface. However, most of these Tertiary podsoils are now largely eroded.

#### *Climate.*

##### (1) Rainfall.

From an average of 45 inches on the coastline, the rainfall diminishes to the west, especially in the Sydney Plains, but gradually increases with altitude on the tablelands (see Text-fig. 4).

Thus in the Sydney Plains, the rainfall diminishes to less than 30 inches, so that a low rainfall basin approximately corresponds to this physiographic region. Another interesting feature is that in this area, the Richmond-Windsor district experienced seven dry years out of a 35-year period, and Picton, Camden, Penrith and Parramatta experienced 5, 4, 3, and 1 dry years respectively, while the surrounding coast and plateau areas were wholly exempt from dry years. The increase with altitude is shown in the Blue Mts., where at Katoomba the mean annual figure is 55 inches, though west from here it again falls to 37 inches at Mt. Victoria.

\* Employing a modified classification of Koppen's, Lawrence (1937) has plotted the incidence of individual desert, dry and humid years in N.S.W. for the period 1900-35.

Two important variations occur in the coastal average rainfall in the Illawarra district. These are a dry area near Dapto, where the rainfall falls below 40 inches, and a moist area in the vicinity of Kiama extending inland to Robertson, where an average of 60 inches is obtained. These variations have a marked effect on the vegetation.

The following mean monthly and annual figures\* indicate the variation in the amount and distribution of the rainfall received over the central coastal area. A double maximum is characteristic (see Text-fig. 5).

TABLE 4.

Station.	Height* Above Sea- Level, Ft.	No. of Yrs. Record.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year. Points.
Sydney .. .. .	67	77	357	426	486	550	512	472	486	287	291	286	284	295	4,732
Parramatta .. .	50	69	342	356	402	350	293	284	317	205	218	233	240	291	3,561
Penrith .. .	89	39	278	286	204	274	213	186	203	154	178	199	240	322	2,917
Windsor .. .	51	38	270	256	267	280	229	180	275	161	170	178	217	266	2,740
Gundagai .. .	222	52	335	253	322	286	218	249	286	156	166	192	229	291	2,983
Pictou .. .	552	56	328	292	337	306	227	240	261	155	192	230	228	300	3,096
Springwood .. .	1,218	48	420	452	500	382	270	264	296	193	200	252	325	372	3,992
Katoomba .. .	3,336	50	593	649	633	529	392	441	456	307	324	311	382	527	5,535
Mt. Vitoria .. .	3,424	63	357	418	377	329	287	310	324	219	249	250	292	343	3,755
Hornsby .. .	594	12	316	450	434	641	382	343	379	147	277	270	343	372	4,354
Wollongong .. .	56	61	445	468	468	539	447	498	393	227	284	267	273	358	4,577
Robertson .. .	2,427	46	581	543	670	549	517	582	649	376	394	362	328	504	6,055
Bowral .. .	2,210	51	371	306	376	322	291	343	386	220	230	232	252	346	3,675
Nowra .. .	26	38	396	339	339	392	424	355	420	238	245	250	223	349	3,970

\* The height given is that of the local railway station.

At Sydney, the evaporation rate exceeds precipitation during the late spring and early summer months (October to January inclusive), which are thus relatively dry. This is shown in the following table.

TABLE 5.

	No. of Yrs. Record.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Evaporation points .. .	56	538	424	365	261	183	144	153	194	271	390	462	539	3,930
Rainfall points .. .	77	357	426	486	550	512	472	486	287	291	286	284	295	4,732

## (2) Winds.

The south-east and north-east winds are responsible for most of the rainfall over the area.

\* I am indebted to Mr. Mares, of the Weather Bureau, Sydney, for meteorological data.

The westerlies are prevailing winds during the autumn, winter and early spring months, as is shown in Table 6. These are desiccating in summer, cold in winter. Throughout the central coastal area, wherever the topography permits the comparison of easterly and westerly facing slopes, the influence of westerly winds on the vegetation becomes obvious. The effect is particularly marked in the Blue Mts. and Hornsby Plateau where the forests are frequently replaced by scrub or scrub-forests in habitats exposed to westerly winds. Onshore winds exert a similar influence in that they stunt the vegetation of the coastal headlands (Pl. xvi, fig. 5).

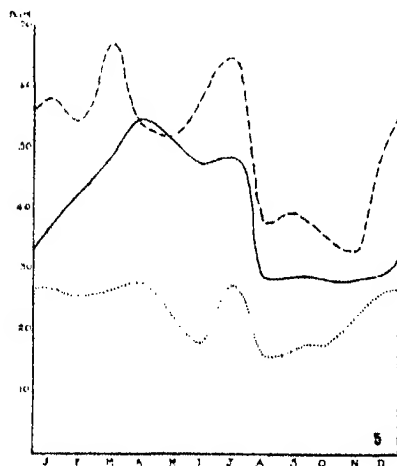
Table 6 shows the prevailing direction of winds for Sydney at 9 a.m. and 3 p.m., expressed as monthly averages over a period of 69 years.

TABLE 6.

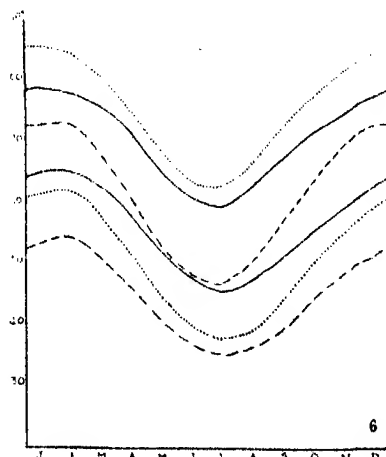
Prevailing Direction.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
9 a.m. . . . .	NE	NE	W	W	W	W	W	W	W	W	ENE	ENE
3 p.m. . . . .	ENE	ENE	ENE	ENE	NE	W	W	NE	NE	ENE	ENE	ENE

### (3) Temperature.

Extremes of temperature are infrequent on the coast, but on the Sydney Plains and at high altitudes on the plateaux the range is considerable; the mean daily range at Sydney is 14 F. degrees, compared with 25 F. degrees at Richmond, 26 F.



Text-fig. 5.—Graph showing the mean monthly rainfall at Robertson (broken line), Sydney (unbroken line), and Windsor (dotted line).



Text-fig. 6.—Graph showing the mean maximum and minimum monthly temperature at Richmond (dotted line), Sydney (unbroken line), and Mt. Victoria (broken line). At each station the uppermost line represents the mean maximum reading.

degrees at Picton and 23 F. degrees at Bowral. On the plateaux the winter temperatures are much lower than on the coast, and snow frequently falls. The average annual temperature for the whole area is approximately 63° F.

Table 7 gives the mean monthly maximum and minimum temperatures at different localities (see also Text-fig. 6).

TABLE 7.

Station.	No. of Yrs. Record.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Sydney														
Mean max. °F.	73	78.4	77.7	75.7	71.3	65.5	61.1	59.8	62.8	67.0	71.3	74.4	77.1	70.2
Mean min. °F.	73	64.9	65.0	62.9	58.1	52.2	48.3	45.9	47.5	51.4	55.8	59.6	62.9	56.2
Parramatta—														
Mean max. °F.	16	83.0	81.8	79.5	74.9	68.8	64.1	62.6	66.2	71.6	75.3	79.4	82.3	74.1
Mean min. °F.	16	62.0	61.9	58.2	53.0	47.2	42.8	41.2	41.7	46.8	51.3	56.4	60.4	51.9
Wollongong—														
Mean max.	57	79.2	78.7	76.8	72.6	67.1	62.7	61.8	64.4	68.6	72.4	65.1	77.6	71.4
Mean min.	57	62.3	62.6	60.4	56.3	51.3	47.8	46.0	47.0	50.4	53.7	57.1	60.4	54.6
Richmond—														
Mean max.	24	85.2	84.2	80.6	74.8	68.6	63.6	63.0	66.2	72.2	77.3	81.7	84.5	75.2
Mean min.	24	61.6	62.0	57.9	51.8	44.9	40.1	38.0	39.5	44.4	50.4	55.3	59.6	50.5
Picton—														
Mean max.	24	85.4	84.1	80.5	75.0	68.1	62.9	61.9	65.1	71.0	75.8	80.1	83.6	74.5
Mean min.	24	59.6	60.2	54.9	48.9	42.7	38.4	36.4	37.3	41.7	47.8	53.2	57.9	48.2
Bowral—														
Mean max.	21	79.4	79.2	74.2	67.1	59.9	53.9	53.1	56.8	63.6	70.0	75.9	78.9	67.7
Mean min.	21	54.3	55.1	51.6	44.9	40.0	36.1	34.6	36.1	40.8	44.7	48.0	52.3	44.9
Mt. Victoria—														
Mean max.	19	72.8	72.9	67.8	60.7	53.1	48.5	47.0	50.6	57.2	63.6	69.6	72.7	61.4
Mean min.	19	53.3	54.6	51.0	46.4	41.0	37.4	35.4	36.5	39.8	44.5	48.6	51.3	45.0

## (4) Relative Humidity.

Table 8 shows the relative humidity values for several different localities in the area. Figures are not available for local variations such as occur in different topographical habitats, e.g., in moist gullies sheltered from wind and sun there is a definite micro-climate characterized by high atmospheric humidity. Such conditions are important in that they favour the development of rain-forest species.

TABLE 8.

Station.	No. of Yrs. Record.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Sydney	73	67	71	72	76	78	78	76	72	66	63	63	64	70
Wollongong	23	75	76	76	76	75	76	75	71	68	69	69	73	73
Parramatta	16	63	69	70	73	76	77	75	68	63	59	58	61	68
Richmond	24	64	69	70	75	79	80	76	71	63	60	59	61	69
Mt. Victoria	20	71	74	75	77	79	82	83	75	60	65	63	67	73



## (5) Sunlight.

The intense sunlight is a feature of the climate, and is partly responsible for the sclerophyllous nature of the plants. Table 9 gives the mean monthly hours of sunshine over a period of 15 years at Sydney.

TABLE 9.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Mean hours of sunshine.	229.2	206.2	201.3	184.4	174.8	158.2	186.3	221.4	218.3	240.3	230.6	225.3	2476.3

The amount of sunlight received in any area depends on the topography; open undulating country and the tops of ridges and uplands receive the maximum amount, while valley floors and slopes, especially south and south-east slopes, are in shadow part of the day. Direct sunlight penetrates the canopy of Eucalyptus forests, but reaches the ground in rain-forests only through occasional light breaks.

*Biotic Factors.*

Much of the vegetation of the central coastal area has been disturbed or entirely cleared since the advent of settlement. Most of the coastal rain-forests have been partially cleared owing to the economic value of one of its trees, *Cedrela australis* F.v.M., whilst other patches on volcanic soil have been cleared for dairy farms. Since the best timber and soils in this area are found in the coastal plains, especially in the Illawarra, partial clearing and selective cutting were inevitable. However, patches of relatively undisturbed forests on the foothills of the scarp and elsewhere, and isolated trees occurring throughout the plains, are sufficient indication of the original vegetation.

The Sydney Plains have been extensively cultivated and used for pastoral purposes for nearly 150 years, so that it is not surprising that most of the vegetation in this area has been disturbed (Pl. xvi, fig. 1).

Except in areas of urban extension, the Hawkesbury Sandstone flora is relatively undisturbed by man. As a result of settlement, however, bush fires are of annual occurrence, and in some seasons very extensive areas of the flora are damaged. There are several large reserves: Kuring-gal Chase in the Hornsby Plateau and the Catchment Area in the Nepean Ramp.

## THE VEGETATION.

As previously stated, the two plant-formations occurring in the area are sub-tropical rain-forest and *Eucalyptus* forest. The forests, even before clearing, did not form a continuous cover, patches of seral vegetation occupying a few areas, such as coastal dunes and wind-blown sands, swampland, scrubland, etc.

*Sub-tropical Rain-Forest.*

These forests, locally known as "brush", although now present only as depauperate remnants, once covered the slopes and valleys of the Illawarra from Bulli to Berry, growing on the loams derived from the Permian rocks, and on the rich basaltic soils. Rain-forest also extended to the basalts at Robertson

(see p. 329). Throughout the whole of the Illawarra plain relics of rain-forest are now practically restricted to creek banks and valleys in the foothills (Pl. xvi, figs. 7, 8), but the widespread occurrence of the Cabbage-tree Palm, *Livistona australis* Mart., which is a typical component of rain-forest in this area, indicates a former extensive distribution (Pl. xvii, fig. 9). One of the largest remnants occurs on the lower slopes of the Illawarra scarp at Bulli, chiefly on Narrabeen Shales and Upper Coal Measures.

Remnants of sub-tropical rain-forest also occur on the chocolate shales in the Gosford district, particularly in the shelter of valleys; and as a fringing forest along Bola Creek, National Park, on the same formation.

On the basalt residuals of Mt. Wilson (Brough, McLuckie and Petrie, 1924), Mt. Tomah, etc., and in the valleys of the Blue Mts. (Pl. xvii, fig. 10), a poorer type of rain-forest occurs. It is not so rich floristically as the sub-tropical rain-forest, and has an admixture of sclerophyll types. Fraser and Vickery (in MS.) refer to this as impure sub-tropical rain-forest. The latter also occurs, to a minor extent, in a few of the coastal gorges, usually where Narrabeen Shales outcrop. These habitats have a definite micro-climate, in that they are sheltered from winds and extreme insolation, and relative humidity and soil-moisture conditions are favourable.

At Grose Vale, a sheltered habitat on the eastern scarp of the Blue Mts., remnants of rain-forest occur on the ostracod soils of the Wianamatta Series, but are now so damaged that it is impossible to ascertain their original floristic composition.

It is obvious that, in the central coastal area, rain-forest is typical of the better class soils receiving a moderately high rainfall. Its absence from parts of the basalt at Mt. Wilson is attributable only to exposure. In the development of rain-forest, high soil-moisture content is more important than chemical composition of the soil, as illustrated at Mt. Wilson, where rain-forest is absent from exposed basalt-soils, but occurs in the shelter of the Hawkesbury Sandstone valleys. The sandstone soils are here enriched by basalt wash, and have a fairly high humus content. It is interesting to note, however, that on sandstone the floristic composition of the impure sub-tropical rain-forest contains a stronger admixture of sclerophyll types than that occurring on the better soils.

In favourable habitats on the sandstone, hardier marginal rain-forest species are frequently admixed with sclerophyllous types to form a true ecotone.

#### *Eucalyptus* Forest.

##### (1) General Structure.

This is essentially a sclerophyll forest of tall-growing *Eucalyptus* trees, but the average height varies from 30 feet to more than 200 feet, according to habitat conditions. The canopy is usually continuous, but differs from that of rain-forests in being much thinner. Thus a considerable amount of sunlight penetrates to the ground; this feature is accentuated by the pendent nature of *Eucalyptus* leaves. The undergrowth forms a continuous ground-cover except on sandstone formations, where it is interrupted by extensive outcrops of rocks and boulders. In typical *Eucalyptus* forests, the undergrowth may be said to consist of a continuous ground-cover of herbs and grasses, with a scattered assemblage of shrubs. The shrubs most frequently form two interrupted layers. The low shrubs may be considered as those not exceeding 6 feet, and averaging about 3-4 feet; the tall shrubs are usually under 12 feet. The shrub strata vary considerably in density from

abundant and continuous to scanty and discontinuous, and frequently form local thickets. Generally speaking, smaller shrubs are more abundant.

The variations in the undergrowth are largely controlled by edaphic and climatic factors; e.g., in the sandstone forests a shrubby undergrowth predominates, whilst the forests typical of Wianamatta Shale are characterized by an herbaceous ground-cover. Elsewhere, more specific habitat factors, such as topography, degree of shelter, and moisture, are chiefly responsible for variations in the undergrowth, e.g., sclerophyll shrubs are most abundant in habitats exposed to greatest insolation, such as plateau surfaces, whilst moisture- and shade-preferring shrubs and herbs are abundant along creek banks and gully slopes, etc.

## (2) The Associations.

Following Clements' system of classification, many distinct associations are recognized within the *Eucalyptus* forest formation. Those present in the central coastal area are mentioned below. Two of these, the Mixed *Eucalyptus* Forest Association and the *E. hemiphloia*-*E. tereticornis* Association are typical of, although not confined to, the central coastal region; the others are interpreted as local expressions of associations more widely distributed elsewhere.

### Mixed *Eucalyptus* Forest Association.

The Mixed *Eucalyptus* Forest Association is typical of sandy-loam soils derived from the Hawkesbury Sandstones, Upper Marine sandstones and certain sandstones in the Newcastle Coal Measures. This association is almost limited to the central coastal area, although local expressions of it occur further south.

It is a distinctive and unique association, differing from most of the coastal forests in its extremely low integration. It is characterized by a large number of dominants in any one stand, and a well developed scrubby undergrowth. Several of the dominant tree species range throughout the association whilst others are limited by such factors as latitude and altitude. In the coastal districts, the most important trees are *Eucalyptus haemastoma*, *E. mirrantha*, *E. piperita*, *E. Siebertiana*, *E. eugenioides*, *E. gummiifera*, *Angophora lanceolata*, *E. pitularis* and *E. punctata*. At higher elevations (Blue Mts. and Moss Vale) the last four species are absent or unimportant, whilst other species occurring in this association are restricted to these areas, e.g., *E. radiata*, *E. maculosa*, *E. Blaxlandi*, *E. oreades*, etc.

This forest association frequently merges into a "scrub-forest" in which the stand of timber averages only 30-40 feet and is rather more open than in typical forests, whilst the growth of shrubs is correspondingly greater. Scrub-forest is of frequent occurrence on the uplands of the Blue Mts. and Hornsby Plateau (Pl. xvi, fig. 4), as a result of exposure to strong westerly winds and insufficient soil-water reserve. In the most unfavourable of these areas the forest is entirely replaced by a low-growing scrub or heath.

The tallest forest communities in this association attain a height of 80 feet or more and occur on slopes and in gullies where conditions of soil moisture, soil depth, shelter, temperature and humidity are most favourable.

Although this forest association occurs in areas receiving moderately high rainfall, the soil conditions are unfavourable in that, as well as being poor in mineral plant-foods, the sandy, shallow and porous soils are frequently excessively drained. On the other hand, on level areas on the plateaux the drainage is often deficient, and these habitats are characterized by a type of swamp vegetation,

\* Authorities for *Eucalyptus* spp. mentioned in this paper are recorded in the appendix.

especially well-developed west of Bulli where the plateau is not dissected (Davis, 1936).

Following Clements' system of naming the association after the two most widely distributed and characteristic dominants, Petrie (1925) suggested the tentative nomenclature of *E. piperita*-*E. haemastoma* var. *micrantha* for this association as it occurs in the vicinity of Mt. Wilson. He also pointed out that this term would be inadequate when the association was studied more widely. This has proved to be so, and by reason of the large number of widely distributed dominants, it has been found impossible and undesirable to attempt to name this association by two species. It seems more desirable that the name used should imply a variety of dominants, hence this unit is referred to as the Mixed *Eucalyptus* Forest Association.

According to the system of classification adopted here, the *E. Sieberiana*, *E. piperita* and *E. pilularis* associations described by Davis (1936), rank only in the nature of consociations within the more extensive and more widely distributed Mixed *Eucalyptus* Forest Association. Davis is here using the term association in a smaller sense of the word.

#### The *Eucalyptus hemiphloia*-*E. tereticornis* Association.

This association characterizes the Wianamatta Shale soils in the low-rainfall basin of the Sydney Plains. Another fragment occurs in the Dapto district (Illawarra) on Permian shales (see page 329).

The vegetation of the Sydney Plains has been converted by partial clearing into a park land or open savannah woodland, with a ground cover of pasture grasses, partly native and partly exotic. However, from remnants of the original vegetation, and from natural secondary growths, it seems fairly certain that the area was originally thinly forested. In the driest areas at least, the *E. hemiphloia*-*E. tereticornis* association probably approached a woodland tree-spacing. This association may be interpreted as an ecotone community showing structural features intermediate between the savannah woodland and *Eucalyptus* forest formations. This interpretation is supported by a consideration of the climatic conditions, since the average rainfall figures for the Sydney Plains approximate more to those of the western slopes than the coastal area.

The original undergrowth in the *E. hemiphloia*-*E. tereticornis* association probably consisted of a large percentage of grasses and herbaceous types, and possibly a number of geophytes with relatively few shrubs. In the regeneration of the undergrowth after clearing, the dominance of native pasture grasses is most marked. *Bursaria spinosa* Cav. is a shrub which is apparently well adapted to the habitat conditions, as it is an almost constant species in regenerating areas.

In the Sydney Plains, the dominant trees of this association are *Eucalyptus hemiphloia*, *E. tereticornis*, *E. siderophloia*, *E. sideroxylon*, *E. crebra*, *Angophora intermedia* and *A. subvelutina*.

*E. hemiphloia* forms a consociation characteristic of the drier parts of the association, this species being apparently especially tolerant of alternating soil conditions of desiccation and water-logging.

The *E. tereticornis* consociation represents a slightly moister phase in this association, and thus is more frequent than *E. hemiphloia* in the Illawarra.

#### The *E. maculata*-*E. paniculata* Association.

*Eucalyptus maculata* occurs in this area as a consociation on shaly sandstone soils, chiefly of the Upper Marine Series in the Nowra district. It is often pure (Pl. xvii, fig. 11), but in the Nowra district is frequently associated with

*E. paniculata* and *E. pilularis*, and also with *E. micrantha* and *E. gummifera* in the more sandy areas. Fragments of the *E. maculata* consociation occur on the light alluvials in the Illawarra. This consociation is also found as an ecotone community between the mixed *Eucalyptus* forest and the *E. hemiphloia*-*E. tereticornis* association, where the soil is a mixture of shale and sandstone. It also reappears in the vicinity of Lake Macquarie on the sandy shales of the Coal Measure and Narrabeen Sandstones. It is present on the latter formation on the foreshores of Pittwater (Broken Bay).

When not occurring in almost pure stands, *E. maculata* is most frequently associated with various species of Ironbark, such as *E. paniculata* in the Bateman's Bay district, south of the central coastal area, *E. crebra* in the Hunter River Valley, and *E. siderophloia* in the Brisbane district, Queensland. Thus *E. maculata* may be tentatively regarded as belonging to the *Eucalyptus maculata*-*E. paniculata* Association.

#### The *E. saligna*-*E. pilularis* Association.

This association is typical of the well-watered loams on the coastal plains. It is one of the most widespread coastal associations. In this area *E. saligna* is best represented on the rich loams derived from the Narrabeen Shales, i.e., in the northern Illawarra and north of the Hawkesbury River. On these loams in the Illawarra, *E. saligna* is associated with *E. quadrangulata*, both of which extend into the rain-forest. North of the Hawkesbury, *E. Deanei* (Pl. xvii, fig. 12) and *E. acuminoides* frequently occur with *E. saligna*. *E. pilularis* occurs throughout the coastal plains either as a dominant, or co-dominant with *E. saligna*. Another fairly widespread species is *Syncarpia laurifolia*. *E. paniculata* (Pl. xvii, fig. 13) also occurs, but is not abundant in this association.

On the valley slopes in the Blue Mts., merging into rain-forest, the association is represented by a community of *Syncarpia laurifolia*, *Casuarina torulosa*, *Angophora intermedia* and *E. Deanei*.

In valleys in the coastal area and Blue Mts., the sub-dominants occurring in this association are moisture-preferring and may include ferns, tree-ferns, and a few of the harder rain-forest species. This type of forest has been referred to as wet sclerophyll forest. It frequently occurs around the margins of rain-forest.

Although *E. pilularis* occurs in wet sclerophyll forest, it is also present in drier habitats and on lighter loams than those supporting *E. saligna*. In such habitats, *E. pilularis* is often associated with *E. paniculata*.

The *E. saligna*-*E. pilularis* Association is widespread in the northern parts of the coast of New South Wales. Important species here are *E. grandis* and *E. microcorys*. The latter occurs at Lake Macquarie, in the central coastal area, which is about its southernmost range.

#### The *E. viminalis*-*E. obliqua* Association.

The widely distributed *E. viminalis*-*E. obliqua* Association, which is characteristic of the cool tablelands throughout the coast of south-eastern Australia, occurs in small patches at high elevations in the central coastal tablelands. The *E. gonitocalyx*-*E. Blaxlandi* association described by Petrie (1925) and Petrie and McLuckie (1926) at Mt. Wilson, is interpreted as a local expression of the larger *E. viminalis*-*E. obliqua* Association.

At Moss Vale and Robertson the chief species belonging to this association are *E. obliqua*, *E. fastigata* and *E. Lindleyana*. They occur on fairly good loams, partly derived from basalts on the uplands, but this association also extends into the valleys. At Bowral, *E. viminalis* is typical of the soils derived from trachytes.

In the Blue Mts., *E. viminalis* occurs on the basalts and in the valleys, whilst *E. fastigata* is also present in the valleys. *E. gonolocalyx* occurs on the basalt-capped areas with *E. viminalis*, but is typical of light sandy loams in the upper parts of the valleys. In the drier western section of the Blue Mts., *E. rubida* and *E. dives* represent the association. *E. Smithii* is another species belonging to this association and is typical of the warmer and moister tableland area bordering the Illawarra.

#### The *E. pauciflora*-*E. stellulata* Association.

The *E. pauciflora*-*E. stellulata* Association, which characterizes the areas of the tablelands approaching sub-alpine conditions, is represented in the locality west of Moss Vale. Here, these two species are associated with *E. radiata*. These forests are rather low-growing and open in structure, and approach more to the woodland than forest formation.

Consociations, or, more strictly speaking, consocieties, which are typical of the coastal plains and occur throughout the whole of the *Eucalyptus* forest formation, are *E. amplifolia* (Pl. xvii, fig. 14) and *E. robusta*. *E. amplifolia* is typical of freshwater swampy flats, frequently on heavy soils. *E. robusta* forms a typical hind-swamp or lagoon forest on the coastline. It is often associated with *E. botryoides*.

#### Minor Vegetation Types.

These are chiefly in the nature of seral communities or relatively permanent vegetation types induced by unfavourable habitat conditions. In the latter category are scrubs and swamps in upland areas.

Low-growing scrub or heath vegetation has already been mentioned in connection with the Mixed *Eucalyptus* Forest Association, in which it occurs on shallow porous sandy soil on ridges and uplands exposed to westerly winds. A similar type of scrub occurs on the coastal headlands (Pl. xvi, fig. 5) where the stunting of the vegetation is caused by strong onshore winds.

On the uplands in badly-drained areas, due either to the nature of the underlying rock or to the configuration of the local topography, a swamp vegetation persists as the climax of a deflected succession. The plants composing the swamp are low-growing sedge-like plants, many of which are hemicryptophytes, and a few shrubs. A particularly large swamp, known as the Wingecarribee, occurs in the district west of Robertson. Relatively smaller swamps are typical of, and occur scattered over, the sandstone uplands.

Of the seral communities, the most important are the successional phases initiated on sand-dunes, in salt-water (Collins, 1921) and fresh or brackish water, all of which culminate in *Eucalyptus* forest.

The seral phases of the psammosere are well known as the strand flora, the sand-binding grasses, the hummock-building mat chamaephytes and the dune scrub passing into *Eucalyptus* forest. The earliest stages of this succession are found on almost every beach, but the hind-dune forests are generally very disturbed as a result of settlement.

The hydrosere initiated on mud flats of the salt-water estuaries of Port Jackson, the Hawkesbury River, etc., are characteristically zoned in the following sequence: Mangroves, *Salicornia* salt meadow, grass meadow, rush meadow, *Casuarina* swamp forest and *Eucalyptus* forest.

The zonation occurring on the margins of lagoons or other fresh or brackish water consists of submerged and floating communities, amphibious and emerged

communities of rush and sedge meadows, and finally, as before, *Casuarina glauca* forest which here passes into a swamp forest of *E. robusta* and *E. botryoides*.

#### CONCLUSIONS.

Sub-tropical rain-forest can be regarded as a post-climax formation (Clements, 1916, 1936) whilst the *Eucalyptus* forest formation is the climatic climax of the coastal area.

In the delimitation of the *Eucalyptus* forest associations in the central coastal area, it is evident that the edaphic factor is the most important. At the same time, individual species have a fairly wide range of soil types and habitats. One such species is *E. pilularis* which is an important member of the Mixed *Eucalyptus* Forest, the *E. saligna-E. pilularis* and the *E. maculata-E. paniculata* Associations.

Under nearly identical climatic conditions, soil type differentiates the following associations: Mixed *Eucalyptus* Forest, *E. saligna-E. pilularis* and *E. maculata-E. paniculata*. Sub-climatic rather than edaphic factors control the distribution of the *E. pauciflora-E. stellulata* and *E. riminalis-E. obliqua* Associations, while a combination of both factors controls the development of the *E. hemiphloia-E. tereticornis* Association.

Two of the most extensive associations in the area show features which are peculiar when compared with the rest of the *Eucalyptus* Forest formation. The *E. hemiphloia-E. tereticornis* Association, by reason of its habitat conditions, is not a true forest throughout its extent, but shows features intermediate between the coastal forests and woodlands of the western slopes.

The Mixed *Eucalyptus* Forest Association, owing to its low integration and general expression as a "scrub-forest", is also differentiated from the typical coastal forests. Following Clements' system of terminology, this vegetation type would be classified as an associes. It is preferably interpreted in the nature of an edaphic climax in the sense of Tansley (1935), since it is in an apparently permanent condition and "in equilibrium with all the incident factors", the most important of which is the unfavourable edaphic factor.

Within this edaphic climax sandstone vegetation, there is a series of physiographic climaxes which represent the successional development. This aspect will be discussed in a subsequent paper.

#### SUMMARY.

As an introduction to a series of papers on the ecology of the central coastal area, the general environmental features are discussed as geological, physiographic, edaphic, climatic and biotic factors.

A general description of the vegetation is given. Two plant formations are recognized: Sub-tropical rain-forest and *Eucalyptus* forest. The former is a post-climax coastal vegetation type, while the latter is the climatic climax formation of the coast and tablelands of New South Wales.

The conditions controlling the development of rain-forest are high soil-moisture, a certain degree of shelter, and a moderately good soil, so its occurrence is necessarily restricted.

The ecological features of the sub-tropical and impure sub-tropical rain-forests occurring in this area are not included here, since Fraser and Vickery (1937 MS, a, b) discuss their structural characteristics and general floristic composition.

The various types of *Eucalyptus* forest occurring in the central coastal area are classified as associations according to Clements' system, but with a slightly modified nomenclature including Tansley's conception of climax communities.

Of the associations recognized, the Mixed *Eucalyptus* Forest and the *E. hemiphloia*-*E. tereticornis* Associations are typical of the central coastal area. The others, namely, the *E. saligna*-*E. pilularis*, *E. maculata*-*E. paniculata*, *E. riminalis*-*E. obliqua* and *E. pauciflora*-*E. stellulata* Associations, are only local expressions of much more widely distributed associations. *E. robusta* and *E. amplifolia* are consociations occurring throughout the coastal belt and not limited to any one association.

Fraser and Vickery (1937 MS, b) discuss the *E. saligna*-*Syncarpia laurifolia*, *E. hemiphloia*-*E. tereticornis*, *E. riminalis*-*E. obliqua* and *E. pauciflora*-*E. stellulata* Associations in the Barrington Tops district.

Davis (1936) has also recorded a local expression of the *E. saligna*-*E. pilularis* Association, but he refers to the consociations as two separate associations.

At Mt. Wilson, Petrie and McLuckie (1925-6) have also recorded the *Eucalyptus* Forest Association and the local expression of the *E. riminalis*-*E. obliqua* Association.

These records from different localities indicate the fragmentary nature of the coastal *Eucalyptus* Forest Associations.

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#### Appendix.

<i>Angophora intermedia</i> DC.	<i>Eucalyptus grandis</i> Maiden	<i>Eucalyptus punctata</i> DC.
<i>lanceolata</i> Cav.	<i>gummifera</i> Gaertn.	<i>quadrangulata</i> Deane and
<i>subvelutina</i> F.v.M.	<i>haemastoma</i> Sm.	Maiden
<i>Casuarina torulosa</i> Alt.	var. <i>micrantha</i> DC.	<i>radiata</i> Sieb.
<i>Eucalyptus amentoides</i>	<i>hemiphloia</i> F.v.M.	<i>robusta</i> Sm.
Schuau.	<i>Lindleyana</i> DC.	<i>rubida</i> Deane and Maiden
<i>amplifolia</i> Naudin.	<i>maculata</i> Hook.	<i>saligna</i> Sm.
<i>Blaxlandi</i> Maiden and	<i>maculosa</i> R. T. Baker	<i>siderophloia</i> Benth.
Cambage	<i>micrantha</i> DC.	<i>sideroxylon</i> Benth.
<i>botryoides</i> Sm.	<i>microcorys</i> F.v.M.	<i>Siebertiana</i> F.v.M.
<i>crebra</i> F.v.M.	<i>obliqua</i> L'Her.	<i>Smithii</i> R. T. Baker
<i>Deanei</i> Maiden	<i>oreades</i> R. T. Baker.	<i>stellulata</i> Sieb.
<i>dives</i> Schauer	<i>paniculata</i> Sm.	<i>tereticornis</i> Sm.
<i>eugenioides</i> Sleb.	<i>pauciflora</i> Sieb. (= <i>coriacea</i>	<i>cinthialis</i> Labill.
<i>justigata</i> Deane and	A. Cunn.)	<i>Syncarpia laurifolia</i> Ten.
Maiden	<i>pilularis</i> Sm.	
<i>goniocalyx</i> F.v.M.	<i>piperita</i> Sm.	

#### EXPLANATION OF PLATES XVI-XVII.

##### Plate xvi.

- 1.—Sydney Plains, looking south from Grose Vale. The monocline of the Blue Mts. in the distance.
- 2.—A tributary valley of the Kangaroo River showing canyon formation. Mixed *Eucalyptus* scrub-forest on top of sandstone cliffs at left.
- 3, 4.—Typical country in the Hornsby Plateau. Fig. 4 shows scrub-forest of mixed *Eucalyptus* Forest Association in middle-ground, semi-swamp vegetation in foreground.
- 5.—Coastline of sandstone headlands alternating with short sandy beaches, between Port Hacking and Stanwell Park.
- 6.—Narrow coastal plain, Stanwell Park, Illawarra.
- 7.—Illawarra scarp and foothills with plains in left distance, Berry District, looking south. Chiefly rain-forest vegetation.
- 8.—Remnants of sub-tropical rain-forest on foothills at Kiama, Illawarra.

##### Plate xvii.

- 9.—South Coastal plain, Milton. Cleared land with *Livistona australis* as remnants of rain-forest. Secondary growth of *Eucalyptus* spp. in middle background.



10.—Valley in the Blue Mts. showing a creek community of *Todea barbara* with rain-forest in left background.

11.—Forest of *E. maculata*, chiefly secondary growth, Nowra, Illawarra.

12.—High forest of *E. Deanei* with an admixture of mesophytic sub-dominants, Mooney Mooney Creek, Hawkesbury River.

13.—Stand of *E. paniculata* with *Macrozamia* sp. and ground stratum of *Imperata cylindrica* var. *Koenigii*, north of Sydney.

14.—*E. amplifolia* with shrub stratum of *Melaleuca* sp., swampy flats, Nowra.

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# THE CARBONIFEROUS SEQUENCE IN THE WERRIE BASIN.

By S. WARREN CAREY, M.Sc.

With Palaeontological Notes by IDA A. BROWN, D.Sc.

(Plate xviii; five Text-figures.)

[Read 24th November, 1937.]

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- A. Stratigraphical Sections of the Carboniferous Rocks: 1, Woodlands; 2, Turi Valley; 3, Landslide; 4, Royston; 5, Merlewood.
  - B. Palaeontological Notes. (I.A.B.)
  - C. Summary of Fossil Plants.
  - D. Analysis of the Carboniferous Sequence: 1, Correlation of Sections; 2, Sequence of Sedimentation; 3, Sequence of Climates; 4, Sequence of Vulcanism; 5, Sequence of Physiographic Expression.

This paper is a sequel to papers already published on the geology of the Werrie Basin or Syncline (Carey, 1934a, 1934b, 1935; Walkom, 1935). The field work upon which all the papers are based was carried out during the years 1932-4 while the writer was Deas-Thomson Scholar and Science Research Scholar of the University of Sydney. Professor W. R. Browne accompanied the writer in the field on several occasions and has always been ready to discuss the problems that have arisen.

Removal of the author to New Guinea on field-service in the latter part of 1934 has delayed publication. The paper has been prepared in Papua, which has entailed the handicap of great restriction of available literature, but in compensation the writer has been able to profit by the wide experience of Mr. J. N. Montgomery, his senior officer in the Oil Search Ltd. Geological Survey.

In the field area the writer met kindness on all sides, and reference has been made in previous papers to many whose hospitality has been outstanding. The stratigraphical work recorded in this paper was chiefly carried out with the courtesy and hospitality of Mr. and Mrs. Eugene McCarthy of Currabubula, Mr. and Mrs. Bruce Adams and family of "Woodlands", Mr. and Mrs. H. J. Perfrement and Mr. Tom Perfrement of "Merlewood", and Mr. and Mrs. Arnold Perfrement and family of "Royston". The fossil collecting work was much aided by various residents of the district, who joined the writer in collecting expeditions. Among these Mr. Eugene McCarthy, Mr. Tom Perfrement, Mr. Tom Creek, and Mr. Ray Swain of "Melrose", Carrol, may be specially mentioned. Thanks are also due to Mr. H. W. Ison of Currabubula, whose well-known willingness to help others has on very many occasions facilitated transport in the carrying out of this work.

A departure from the usually accepted nomenclature for the divisions of the Carboniferous strata is incorporated in the paper. For the present the name Burindi is retained for the marine series forming the lower part of the sequence, but the original Kuttung Series is divided into a Lower and an Upper Kuttung Series. This change has been necessitated by the discovery of Viséan fossils in the lower half of the Kuttung succession. The stratigraphical implications of this discovery, which are of some importance, it is hoped to discuss shortly in another paper.

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## A. STRATIGRAPHICAL SECTIONS OF THE CARBONIFEROUS ROCKS OF THE WERRIE BASIN.

## 1. THE WOODLANDS SECTION.

The Woodlands section is admirably situated for the examination of the Kuttung series as developed on the eastern limb of the Werrie syncline.

From the Werrie basalts on Anstey's Creek in the Parish of Currabubula, the section-line follows the south boundary of portions 74, 275, 259, 258, and 159 (see Text-fig. 1). The line was not followed further east through the Burindi Series, owing to extensive cultivation and poorness of outcrops.

The highest outcrop of the Burindi beds is found in the second small gully on the road between Woodlands and Glenarvon homesteads, which follows the section-line east of the Currabubula Creek crossing. Here olive-green mudstones are found with numerous dwarfed fossils.

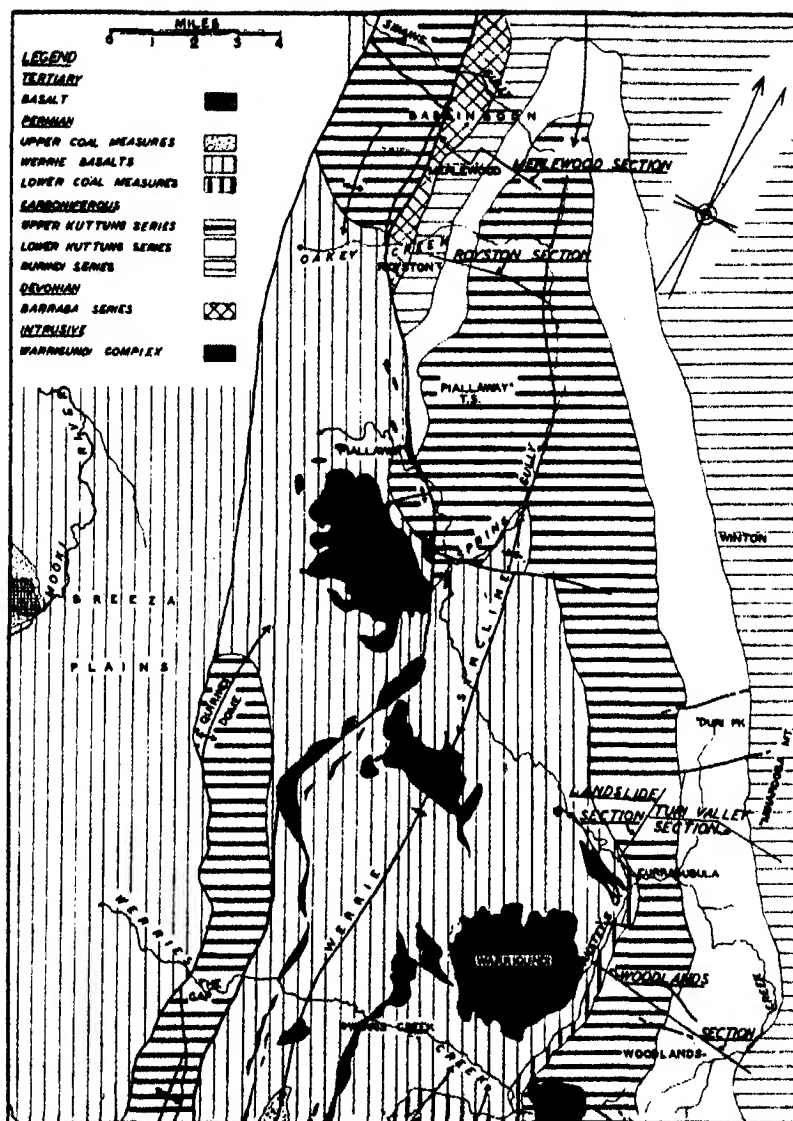
Following the Burindi beds, the base of the Kuttung is concealed under a soil cover. In portion 169, about a mile north of the section line, however, the abundance of shed boulders in the cultivation paddocks indicates that a conglomerate is probably developed there at the base of the series. Next are pebbly and sandy tufts with interbedded sandy shales. One band of the latter is packed with *Rhodesia*-like remains chiefly belonging to the *Sphenopteris* group, and among these are suspected to be some new types. *Lepidodendron Veltheimianum*, *Stigmara ficoides* and *Sphenopteridium* (?) are present.

Between this plant-horizon and the main pyroxene-andesite at Woodlands homestead are well-bedded sandy felspathic tufts of buff, brown, and chocolate colour. Scattered pebbles of granite, aplite and chert, and pebbly bands, are not infrequent. The tufts are typically barren, but odd plant-stems are met with, as well as occasional zones packed with macerated carbonaceous material. As the pyroxene-andesite is approached the conglomeratic phase becomes more abundant, and close below the andesite there is a very coarse boulder-bed resting on finer tufts.

A good exposure of this horizon is to be seen near "Woodlands" homestead a little south of the section-line, where the andesite crosses Currabubula Creek (Portion 44). Here the gritty tuft is followed by ten feet of fine tuft with pebbles, then fifteen feet of conglomerate, becoming coarser upwards, then ten feet of gritty tuft, overlain by about twenty feet of coarse conglomerate with boulders up to two feet in diameter. This is followed by pebbly tuft, then a band of conglomerate, overlain by about fifteen feet of dark chocolate gritty tuft which forms the bed for the andesite flow. Even the coarsest of the conglomerate is crudely bedded, and the boulders are well rounded and without recognizable glacial striae. Granitic rocks are abundant among the boulders, but the largest are porphyritic andesite, with a Devonian lithology (e.g., as in the Barraba Series in the Babbinsboon district) rather than the andesites indigenous to the Kuttung Series.

The total thickness of Kuttung rocks below the pyroxene-andesite is nearly 200 feet. Where the section-line crosses it the andesite flow is 600 feet thick. Following the lava are about 2,300 feet of pebbly and gritty felspathic tufts with occasional conglomeratic horizons. Among the colluvial debris from these beds petrified fragments of *Pitys* are common.

At the top of the Lower Kuttung Series is a discontinuous horizon of pyroxene-andesite flows, of which Duri Peak and Kingsmill Peak are prominent outcrops. On the Woodlands section is a mass of andesite 800 feet thick on this horizon. As with the lower flow, a bouldery conglomerate is developed immediately below the extrusive rock.



Text-fig. 1.—Geological Map of part of the Werrie Basin showing Section-lines and Localities referred to in the text.

The coarse boulder bed which follows the upper pyroxene-andesite zone is the basal conglomerate of the Upper Kuttung Series. Three stages are recognizable: the Lower Glacial, 2,500 feet thick; the Interglacial, 1,000 feet thick; and the Upper Glacial, 1,500 feet thick, making a total thickness of 5,000 feet.

In the basal conglomerate of the Lower Glacial Stage the boulders, which range up to three feet in diameter, are mainly igneous types, such as granites,

both acid and intermediate, pink porphyries with an aplitic appearance, and porphyrites, but few of the types are such as are likely to have been derived from the erosion of the volcanic rocks of the Lower Kuttung. There is no obvious stratification or sorting, but no glacial striae were recognized. Upwards they become less bouldery and have a deep purple matrix.

Overlying the coarse conglomerates is a thick series of gritty tufts. Pebbly and conglomeratic bands of a glacial facies become more numerous as the series is ascended, finally grading into tillites about 900 feet above the base of the stage. The pebbles present a wide variety of types, with a range of fresh igneous rocks, both plutonic and effusive, as well as limestone, chert, quartz, phyllite and schist.

The ensuing glacial beds are at first mostly true tillite, with bands of glacial grits and fluvioglacial conglomerate. In the tillite the pebbles weather uniformly with the matrix and cannot readily be detached, but striated pebbles were dug out from the conglomerates.

The tillites pass up into varves. They are beautifully laminated, with frequent contemporaneous contortions and abundant erratics. This zone is considered to be the equivalent of the Glenoak varve horizon near Seaham (Osborne, 1922, p. 180). Coloured laminated tufts follow the varves, and these are associated with fine-grained beds which have yielded some interesting carbonized petrifications, including the type specimen of *Samaropsis ovalis* (Walkom, 1935, p. 460).

Overlying the plant-bearing tufts is a mass of fluvioglacial conglomerate, 300 feet in thickness. The pebbles, which are similar to those in the earlier conglomerates, but with a greater prevalence of acid lavas which may have originated within the Kuttung, are well rounded, and vary up to a foot in major diameter. Nearly every pebble shows glacial striae or deep grooves.

The deposition of this conglomerate mass was succeeded by a further advance of the glacier and the deposition of varves. The latter are rather coarse, tending towards varve-sandstones, especially near the top. This set of varves represents the culmination of the lower glacial advance, for they are rapidly followed by *Rhacopteris*-bearing grits which initiate the tufts of the Interglacial Stage.

The Interglacial Stage is one of the most resistant physiographic units in the Werrie region, and its cliffs and bluffs always tower above the strike-valleys of the Lower Kuttung. Immediately above the *Rhacopteris* tuff at the base is the pebbly phase of hard white felspathic grit which makes up the bulk of the stage. Then comes about 100 feet of soda-rhyolite tuff. This bed shows considerable lithological variation from a fine-grained green cherty type to a coarse phase with fragments of quartz, feldspar, and green felsite, which grades further into flow-breccia. Overlying the green alkaline tufts is a bed of well-graded breccia. It consists mainly of angular chips of quartz-felsite a little larger than peas. Upwards, this becomes finer and more conglomeratic, and then grades up into white *Rhacopteris*-bearing tuff at the top of the Interglacial Stage.

At the base of the Upper Glacial beds are a few feet of coarse conglomerate with boulders up to a foot in diameter. This conglomerate has a distinctly glacial aspect, and is followed by finer conglomerates which are clearly fluvioglacial, above which is a thin bed of soda-rhyolite tuff, then a very thin felsite flow. Next are two plant-bearing horizons separated by tufts and varves. Seeds of the *Cordaicarpus* type have been collected from the upper of the two plant horizons.

The top 800 feet of the Kuttung are largely glacial. Varves are best developed in the upper part of this section and are underlain by tillite. The remainder is partly fluvioglacial, partly tillitic, and partly tuffaceous.

Resting directly on the Kuttung beds are the Greta Coal-Measures. The lowest bed is a strongly-cemented conglomerate with hard gritty bands. The latter contain abundant plant-impressions measuring up to two feet in length and three and a half inches across. Beneath the conglomerate are hard but fine-grained acid tufts which are well laminated. These are the highest beds of the Kuttung or the lowest of the Greta Series, and they rest on a coarse fluvio-glacial conglomerate made up chiefly of pebbles derived from Kuttung lavas. The lithology of this formation is quite distinct from that of the Greta conglomerates.

## 2. TURI VALLEY SECTION.

The Turi Valley section is suitable for examining the Kuttung sequence from the Interglacial Stage to the Burindi Series, especially the Lower Glacial beds. The section commences on the Travelling Stock Route from Currabubula to Duri, where the Mount Minarooba pyroxene-andesite sill crosses the road. From this point the section-line runs west along the north boundary of portions 283 and 284 (Parish of Currabubula), then turns south along the west boundary of portion 284 to the north-east corner of portion 107. From this point the section follows a bearing of S.63°W. for about two miles, crossing the broad valley of Turi Creek, and ascending the scarp to the top of the cliffs which overhang the valley on the south-west.

The Minarooba sill, which is about 530 feet thick, intrudes the Burindi Series about 700 feet below the base of the Kuttung, and is on the same general horizon as the silicified zone in the Woodlands section, which marks the position underground of the lenticular intrusive sheet there.

The Burindi Series consists of the usual well-bedded, olive-green mudstones which are richly fossiliferous.

At the base of the Lower Kuttung Series, resting directly on the fossiliferous beds in portion 199 (Parish of Currabubula) adjacent to the section-line, are a number of impure coal-seams. In a gully a little above Mr. Howlett's house are at least four seams, the highest of which is about six feet thick on the outcrop, with a band twelve inches from the top. The unweathered seam is probably much thicker. Both the coal-seams and the Burindi mudstones on which they rest are much fractured and jointed by numerous minor dip-faults.

Benson (1920) included the coal-seams in the Burindi Series, but the present writer regards them as marking the base of the Kuttung, for it is at this horizon that the change in lithology from the typical Burindi mudstones to the gritty felspathic and keratophyric tufts, which persist throughout the Lower Kuttung, takes place. The stratigraphical horizon relative to the main pyroxene-andesite flow is closely comparable with the base of the Kuttung on the Woodlands section. *Lepidodendron Veltheimianum*, *Stigmaria ficoides* and *Calamites* are frequent in the lower tufts in much the same state of preservation as in the remainder of the Lower Kuttung.

Petrological descriptions of some of the tufts have been given by Browne (1920).

The main pyroxene-andesite flow, here 860 feet thick, is about 1,100 feet above the base of the Kuttung. As in the Woodlands section, the lava is underlain by a thick mass of heavy conglomerate which is separated from the andesite by a bed of tuff. The boulders average about 10 inches in diameter, but frequently exceed a foot. *Pitys* in silicified blocks occurs in the lower part of this conglomerate, where it crosses the stock-route a little to the east of the section-line,

and the underlying tuffs there yield *Lepidodendron Veltheimianum* and *Stigmaria ficoides*.

The top of the andesite is rather weathered, and is followed by about 20 feet of leached material containing white kaolinitic and carbonated material. This is followed by coarse conglomerate with boulders averaging from eight to ten inches, mostly granitic rocks and hornblende-porphyrite, with occasional pebbles of pyroxene-andesite. The conglomerate is rudely bedded, with some finer bands.

Between the main pyroxene-andesite and the horizon of the Duri Peak discontinuous zone are nearly four thousand feet of strata, mainly felspathic gritty tuffs with pebbly bands and occasional horizons of coarse conglomerate. About 700 feet above the andesite is a conglomerate with pebbles averaging four inches in diameter. In portion 10, roughly on this horizon, a little to the east of the section line, is a good collecting ground for *Stigmaria ficoides* and *Lepidodendron Veltheimianum*.

A thousand feet higher is another conglomerate, with pebbles about six inches in diameter, among which are a good many of pyroxene-andesite. About 600 feet of tuffs separate this from the next conglomerate horizon, where the pebbles are a little smaller.

Near the top of the Lower Kuttung is a stratiform sheet of basalt 100 feet thick. This may be a contemporaneous flow, but such a lava is not usual there. It may be an intrusive, referable to either the Warrigundi or the Tertiary cycle of volcanic activity.

Owing to the down-faulting of the south-eastern end of the Duri Peak andesite, and to its rapid lenticular thinning, the Turi Valley section takes very little account of this flow. Scattered along the strike, however, are numerous blocks of vesicular and scoriaceous andesite. The outcrop is not of the best and it is difficult to decide whether it is the thin tongue-end of the flow or the débris distributed beyond the end of the flow by contemporaneous erosion.

The Lower Glacial beds, which follow the Duri Peak andesite, are more than 3,000 feet thick. The basal conglomerate, which is about 200 feet thick, contains boulders up to two feet in diameter, chiefly of the characteristic granitic rocks and pink porphyries. Silicified remains of *Pitys* are abundant in the lower portion and in the immediately underlying tuff.

Above the conglomerate are about 800 feet of pebbly tuff and conglomerate which makes poor outcrop, and which grades upwards into a thick sequence of fluvio-glacial conglomerate, tillite, and varve, exactly as in the Woodlands section. In these beds erratics of pyroxene-andesite of Kuttung lithology are not uncommon and often exceed two feet in diameter. The more common granitic erratics are often more than a foot across. As before, this zone is separated from the striated-pebble horizon by bright green and red laminated tuffs. The 600-foot fluvio-glacial conglomerate which follows is almost entirely made up of striated pebbles, the hard argillites of the pebbles being particularly adapted to the preservation of the glacial grooves. Erratics of weathered granite up to twenty inches in diameter are also present. Interstratified with this conglomerate is a flow of hornblende-andesite about ten feet thick.

The fluvio-glacial conglomerate is followed by 250 feet of tuffs, then nearly 400 feet of varves, which are the highest member of the Lower Glacial Stage.

The conglomerates which follow, forming the scarp rim, are the basal strata of the Interglacial Stage. They are 100 feet thick, well-graded, and with little suggestion of glacial origin. Overlying them is a series of conglomerates, grits, and tuffs with plant-bearing beds. The late R. H. Cambage collected *Archaeo-*

*calamites* here. These beds are followed by the basal conglomerate of the Upper Glacial Beds, the sequence of which is described in the Landslide section.

### 3. LANDSLIDE SECTION.

The Landslide section which completes the Kuttung sequence through the Upper Glacial Stage, is complementary to the Turi Valley section, which traverses the beds below the Interglacial Stage.

The upper part of the Interglacial Stage, beneath the basal conglomerate of the Upper Glacial beds, consists of plant-bearing grits and tuffs with conglomeratic bands from which *Rhacopteris* and *Cordaites* have been collected. This sequence is nearly 400 feet thick and is injected by several thin keratophyre sills.

The coarse basal conglomerate of the Upper Glacial Stage is 90 feet thick. The boulders, which are well-rounded, average about six inches in diameter, with a maximum of fifteen inches, and include such rock-types as biotite-granite, quartzite and rhyolite. They have been derived for the most part from a pre-Carboniferous terrain.

The varves which follow are 300 feet thick. Contemporaneous contortions occur in the lower portions, and towards the top they become coarser and pass into varve-sandstones.

In the next 400 feet there is evidence of a lull in the glaciation, as the sediments are more normal in character, consisting mainly of conglomerates and tuffs. The conglomerates are well-graded and well-bedded, the average pebble-size being about two and a half inches. Lavas and felsites are most abundant among the pebbles, but keratophyre, porphyrite, rhyolite, limestone, and vein-quartz are also present. The interbedded sandy layers contain abundant carbonized and fragmental plant-material. The upper 200 feet of this Stage are made up almost entirely of creamy-white shales, probably largely tuffaceous in origin, which are packed with *Rhacopteris*. The instability of these beds on a steep dip-slope led to the landslide which gave the section its name.

Following these plant beds a glacial advance is recorded in 80 feet of fluviotill which grades into true tillite. The boulders, up to two feet in diameter, include hornblende-andesite, acid granite, biotite- and quartz-felsites, and rhyolite, as well as quartzite and limestone. The quartzo-felspathic matrix here and there develops a varvoidal structure in which the boulders are not infrequently big end up.

Above the fluviotill is a bold outcrop of soda-rhyolite tuff, 270 feet thick and very uniform in grainsize and lithology. This is at a very much higher horizon than the similar rock in the Interglacial Stage in the Woodlands section. It was the erroneous correlation of these two beds, and of the plant-bearing beds and glacial rocks of the Upper Glacial Stage of the Landslide section with the glacial beds, etc., of the Lower Glacial Stage of the Woodlands section, which led Benson (1920, pp. 307-8) to postulate a very heavy fault along Currabubula Creek (see Carey, 1934a, p. 368). There is a thin bed of soda-rhyolite tuff in the Upper Glacial Stage of the Woodlands section also, but it is not so prominent as in the Landslide section.

The alkaline tuff is followed by 1,000 feet of tillite, conglomerate, varve and tuff. This is exactly analogous to the sequence in the Woodlands section. The tillite is best developed in the lower 300 feet, and the varves are prominent at the top. The tillitic portion seems to have derived its boulders chiefly from a pre-Carboniferous landscape, whereas in the conglomeratic portions, both above and below the tillite, the pebbles are commonly felsites with other acid lavas which appear to have been derived from the Lower Kuttung Series.



The top member of the Kuttung is a 270-foot bed of conglomerate, identical with the rock occupying the same position in the Woodlands section. The pebbles are almost entirely of acid lavas derived from the erosion of the Kuttung. Toscanitic and dellenitic lavas with phenocrysts of quartz and biotite are the most numerous, with hornblende- and pyroxene-andesites less common; the felsites which dominate the conglomerates beneath them are still present but much rarer, while the rocks belonging to the granitic terrain of the tillites are almost entirely absent. The boulders average about six inches, with a maximum of about ten inches.

The total thickness of the Upper Glacial Stage in the Landslide section is about 2,750 feet.

#### 4. ROYSTON SECTION.

The Royston section provides the most complete study of the Upper Kuttung rocks as they are developed in the western limb of the Werrie syncline. The section-line runs from the north-west corner of portion 48, Parish of Babbinsboon, adjacent to 'Royston' homestead, and follows a bearing of N.79°E. to the point on the northern boundary of portion 48 in the Parish of Piallaway, where that boundary descends a cliff. From this point the section runs due east, following the northern boundaries of portions 48 and 49, and continuing within portion 59 as far as Oakey Creek.

This section commences at the western end on a thin bed of limestone in the fossiliferous mudstones of the Burindi Series. Five hundred feet above the limestone is a sheet of pyroxene-andesite thirty feet thick, which is presumed to be a sill. Between this andesite and the limestone, and also above the andesite, are several smaller lenses of the same igneous rock.

About 1,800 feet of strata intervene between the andesite sill (?) in the Burindi Series and the main pyroxene-andesite flow of the Lower Kuttung. Immediately underneath the flow are coarse conglomerates precisely as in the other sections. They are about 320 feet thick, with boulders up to four feet in diameter. The base of the Kuttung lies somewhere between the bottom of the conglomerates and the andesite sill (?). Assuming the constancy of the sill-horizon the thicknesses of strata involved are comparable with those in preceding sections.

The main pyroxene-andesite flow is 370 feet thick. It is mainly composed of the glassy phase (see p. 372), but spheroids of the lithoidal phase are very abundant in it.

Overlying the main pyroxene-andesite flow are 1,400 feet of pebbly felspathic tuffs which make up the rest of the Lower Kuttung. Many silicified fragments of *Pitys* shed from these strata have been found.

The basal conglomerate of the Upper Kuttung makes good outcrops, with boulders up to two feet in diameter. It is about 150 feet thick, and is followed by 200 feet of bedded tuffs, which are overlain by a thick series of varves. The varves have interbedded tuffaceous layers, and are followed by more tuffs which are interstratified with conglomerates rich in ice-scratched pebbles. This is the horizon which has yielded such fine glacial specimens elsewhere. Capping this tuff-glacial series and forming the top of the Lower Glacial Stage is a twenty-foot bed of hard tillite. The total thickness of the Lower Glacial Stage is about 1,000 feet.

The Interglacial Stage is about 1,200 feet thick. At the base are 220 feet of soda-rhyolite-tuff. The rest of the stage is made up of normal conglomerates and tuffs, with many plant-bearing horizons. The conglomerate

at the base of the Upper Glacial Stage is not developed in the Royston section. Resting on the Interglacial Stage are 220 feet of varves, which are followed by 160 feet of hard, blue tuff which outcrops boldly as a line of cliffs. On top of this is a thin bed of creamy *Rhacopteris*-tuff, which has yielded, among other things, *Rhacophyllum*. Next come 370 feet of tufts and fine conglomerates with a tillitic horizon at the top.

The acid lava which follows is characteristic of the western side of the Werrie syncline, though it is usually missing in the eastern limb. It contains phenocrysts of quartz, feldspar and biotite, and is about 300 feet thick, becoming thicker to the east.

On top of the acid lava are 280 feet of varves. These are followed by a veneer of conglomerates and grits completing the section, which does not quite reach the top of the Upper Kuttung.

#### 5. MERLEWOOD SECTION.

The Merlewood area has been mapped in rather more detail than other parts of the region, in order to determine clearly the relationship between the Lower Kuttung Series and the horizons of the fossiliferous marine beds which occur there.

The geological structure is shown in the map of the Babbinsboon district (Plate xviii). Parallel belts of Carboniferous and Upper Devonian rocks dip conformably eastwards as part of the western limb of the Werrie syncline. To the east, the easterly dips continue beyond the limit of the map until the synclinal axis is reached. Westwards the area is bordered by three powerful faults where the imbricate Mooki thrusts emerge. The local trend of the strata is meridional, parallel to the thrusts, and the angle of dip varies between 25° and 50°, with the steeper dips to the west.

Two minor dip-faults have been found, but in either case the throw is less than 100 feet. There are three circular patches of basalt, which probably betoken necks, and a fourth outcrops a little beyond the northern limit of the map. A few basic dykes occur, trending in the dip-direction.

Topographically, the rocks of the Upper Kuttung Series form the high ground on the east and west, with an intermediate depressed belt, about two miles wide, where the Burindi and Devonian rocks lie. The surface forms are mature, with common development of cuestas and hog-back ridges.

Swain's Gully, which rises in portion 34, Parish of Babbinsboon, and flows westwards through portions 14, 15, 62, 58, 16, 17, 36 and 25 of that parish, provides the most informative stratigraphical exposure in the district. It extends from the top of the main feldspathic grit in the Upper Kuttung Series, across the Lower Kuttung with its marine horizon, through the Burindi beds to the Barraba Series.

*Barraba Series.*—The lowest beds exposed are well-jointed mudstones with the ribbon-like banding which is typical of this series. Quartz veins, which have not been encountered in the Carboniferous beds, are not uncommon here. As the Burindi Series is approached, the series becomes more and more bouldery, with rapidly increasing vulcanism, culminating in a very variable bed, about 800 feet in thickness, of what is best described as an agglomerate. Some phases are true conglomerates with well-worn boulders of andesitic lava, but elsewhere the matrix is entirely tuffaceous, and passes into rocks resembling flow-breccias. Finer interbedded tuff-partings near the upper part of this formation have yielded *Lepidodendron australe*. The series seems to reach its maximum coarseness at the top,

immediately beneath the basal conglomerates of the Carboniferous. These quasi-volcanic conglomerates continue to the Tamworth-Gunnedah road which they cross near Carrol Gap, whence they have been traced for some distance to the north-west by A. C. Lloyd (1934).

*Burindi Series.*—Commencing this series is a basal conglomerate with boulders of granite, hornfels, and porphyrite measuring as much as ten inches in diameter. These are overlain by buff-coloured gritty sandstones with current-bedding and some conglomerate bands. The sandstones carry plant-stems, some of which resemble *Calamites*. This basal series is 400 feet thick and shows a progressive change in facies from the heavy conglomerates at the base to the sands and silts at the top. Next in the sequence are well-bedded dark blue marly mudstones and tuffs, which have yielded the fauna listed on page 352, including numerous specimens of *Cladochonus tenuicollis* and *Phillipsia* sp.

Following the marls are laminated olive-green mudstones of typical Burindi facies; about 200 feet above the base of these is a richly fossiliferous band, which is packed with fossils, including some low Lower Carboniferous forms, notably one closely resembling *Protocanites lyoni* M. & W. The forms are listed on page 352.

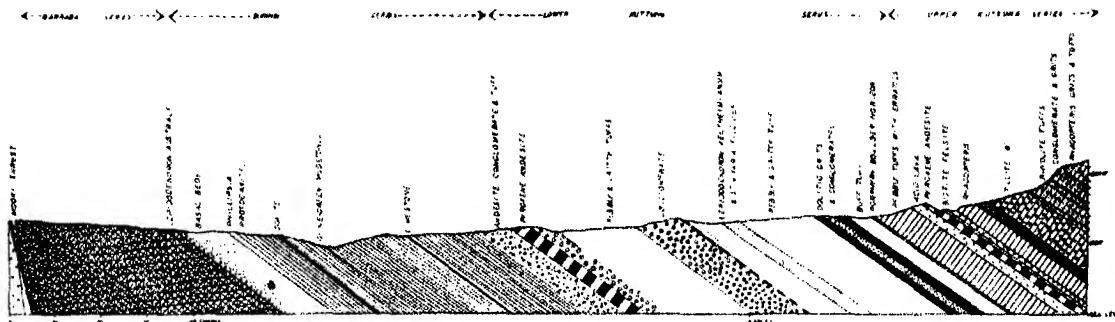
The Burindi Series is on the whole a remarkably uniform series of mudstones, with only occasional tuff-bands. Oolitic limestone is developed as discontinuous lenses on a horizon about 850 feet above the base, a horizon which has been picked up at intervals over a considerable distance. A typical exposure is to be seen in portion 64, Parish of Babbinsboon. Crinoid ossicles, and occasional brachiopods and other fossils are found in the oolite. Limestone bands recur also about 2,000 feet above the base of the series, but these thin lenses are less persistent, and non-oolitic, and contain a good deal of pyrites, which may partially pseudomorph the fossils. The total thickness of the Burindi Series is more than 2,500 feet. Marine fossils and fragments of drift *Lepidodendron Veltheimianum* are quite numerous in the upper 1,000 feet.

*Lower Kuttung Series.*—The base of this series is exposed in the gully in the north of portion 15, close to the point where it crosses into portion 62. The lowest beds are tuffs and conglomerates 340 feet thick which contain *Lepidodendron Veltheimianum*. These are followed by a flow of pyroxene-andesite 200 feet thick, which thins out and disappears altogether in some places. Below the andesite, and along its strike where it is missing, are tuffaceous conglomerates in which the pebbles are pyroxene-andesite similar to the flow. Next follow 200 feet of coarse conglomerates. The boulders, which average about ten inches in diameter but reach as much as eighteen inches, are chiefly of pink granite and a hard porphyry which is resistant to weathering, together with grey quartzite and some volcanic rocks. Overlying these heavy conglomerates are 700 feet of pebbly and gritty tuffs. They are salmon- to buff-coloured on exposed surfaces and are fairly well bedded, with some pebbly layers and occasional plant-bearing horizons.

Above the gritty tuffs is another zone of coarse conglomerate 400 feet thick. Here the pink porphyry and acid granite are still present, as boulders up to two feet in diameter; there is, however, a greater proportion of volcanic rocks than on the lower horizon, especially a purple felsite in boulders as much as 14 inches in diameter.

Overlying this conglomerate are ten feet of reddish biotite-tuff, followed by another flow of pyroxene-andesite, where the section-line crosses it (see Plate xviii and Text-figure 2); this flow is only twenty feet thick but further south it increases to 300 feet. Above the lava is another 300 feet of pebbly and gritty

tuffs, which is followed by 200 feet of rather more resistant grits bearing well-preserved impressions of *Lepidodendron Veltheimianum* and *Stigmaria ficoides*. Some of these plant-stems are very large, one piece of the former being ten inches in diameter and four feet in length. This specimen, portion of which is preserved in the Botany Museum at the University of Sydney, shows impressions which appear to be the lower parts of the leaves still attached to the stem. The plant-bearing bed is followed by another 650 feet of gritty tuffs, which continue until the *Amygdalophyllum-Lithostroton* marine horizon is reached.



**Text-fig. 2.—Merlewood Section.**

On the line of section the marine horizon is very sparsely fossiliferous, and is represented by 270 feet of oolitic grits and conglomerates. The latter are markedly distinct from the other Lower Kuttung conglomerates. The pebbles are much smaller and more evenly sorted, and their lithology and ovoidal form are distinctive; grey quartzites and certain types of lava dominate. Northwards the oolitic zone passes laterally by progressive stages into grits and conglomerates without a perceptible oolitic matrix, but the types, size and system of sorting of the pebbles remain unchanged. A mile further north, in portion 60, richly fossiliferous limestones appear immediately overlying the grits and conglomerates, which here regain in part their oolitic character. *Amygdalophyllum* and *Lithostrotion* are by far the most abundant fossils, but by careful collecting a fairly extensive fauna of Viséan aspect has been obtained.

In view of the fact that this is the first record of marine strata from such a horizon in New South Wales, and that its implications are many and far-reaching, every precaution has been taken to ensure the accuracy of the field-work in the determination of their horizon. As a result it can confidently be stated that all possibility of these strata being infaulted Burindi beds has been eliminated, and it may be regarded as established that their horizon is high in the Lower Kuttung.

Following the oolitic and fossiliferous marine strata are buff-coloured gritty and pebbly tufts with occasional boulders of granite and pink porphyry, some of which are as much as two feet in diameter. These beds are followed by a suite of volcanic rocks. The first flow is an acid-intermediate lava 140 feet thick. Next is a flow of pyroxene-andesite 90 feet thick, probably to be correlated with the Duri Peak andesite; then come 40 feet of biotite-felsite, and finally 70 feet of acid tuff. These lavas are regarded as the equivalents of Osborne's Volcanic Stage in the Lower Kuttung of the Lower Hunter Valley.

*Upper Kuttung Series.*—The lavas are followed by typical Lower Glacial Stage rocks, which are succeeded in turn by the tuffs of the Interglacial Stage. Unfortunately the coarse basal conglomerate of the Upper Kuttung is not present in this part of the area. However, it is well-developed in the Royston section, and a close correlation is possible between the rocks of the Interglacial Stage and the Lower Glacial Stage in the two sections.

Overlying the volcanic rocks are 230 feet of conglomerates, grits, and shales, with well preserved impressions of *Rhacopteris* and *Calamites*. These are followed by 150 feet of varves with interbedded tillite layers which yield striated pebbles.

Next comes a beautiful tillite. Here granite boulders, which are usually weathered, range in size up to three feet, and often rest big end uppermost. With them are large boulders of pyroxene-andesite, pink porphyries and rhyolites, and abundant pebbles of grey quartzite which bear well-preserved glacial striae, all of which are interbedded without much sorting in a dark chocolate matrix.

This glacial horizon, which is the top of the lower glacials, is followed by a varied series of soda-rhyolite tuffs, and other associated pyroclastics, with little detrital admixture. These pass into tuffaceous conglomerates and tuffs, which are in turn overlain by more acid tuffs and grits with *Rhacopteris*, which complete the section. The thickness of strata belonging to the Interglacial Stage is 860 feet, but this does not include the highest beds of that stage.

#### B. PALAEOLOGICAL NOTES. (I.A.B.)

Already a large number of forms (more than 80 species) have been recorded from this area by W. N. Benson (1921). Some have been described in detail, others are provisional determinations of Museum specimens.

At the time when Professor Benson's work was carried out no faunal zoning was possible, but he expressed the hope (1920, p. 370) that "as the detailed stratigraphical study of the Burindi Beds proceeds, accompanied by refined palaeontological work, a regular succession of faunal zones may be shown to exist in this State as elsewhere." The present work is an attempt at such zoning.

Exhaustive collections of the fauna were made by Mr. S. W. Carey from three horizons in the "Merlewood" section. Provisional determinations are given below; detailed descriptions of new and uncommon forms will be given in a later paper.

The lowest horizon is 400 feet stratigraphically above the base of the Burindi Beds, and consists of blue, marly mudstones and tuffs from which the following forms are identified: *Zaphrentis* sp., *Cladochonus tenuicollis* McCoy, Crinoid ossicles, *Fenestella* sp., (?) *Chainodictyon gigantea* Eth. ms., Brachiopod fragments, Gastropod fragments, *Phillipsia* sp.

*Cladochonus tenuicollis* McCoy is the most abundant fossil at this horizon. *Zaphrentis* is rare; it is a small form with a deep calice, showing about 36 septa in a section of 4 mm. diameter.

The second horizon, occurring about 200 feet stratigraphically above the first, contains a variety of specimens preserved in shales and limestone nodules. The following species are provisionally recognized:

<i>Zaphrentis</i> aff. <i>cliffordana</i> E. & H.	<i>Productus</i> sp. (cf. <i>P. semireticulatus</i> Martin).
<i>Zaphrentis</i> sp.	<i>Productus</i> sp.
Crinoid ossicles	<i>Camarophoria</i> (?) sp.
<i>Fenestella</i> sp.	<i>Dielasma sacculum</i> var. <i>hastata</i> Sow.
<i>Schizophoria resupinata</i> Martin	<i>Spirifer</i> aff. <i>mosquensis</i> F. de W.
<i>Chonetes</i> sp. (cf. <i>hardensis</i> Phill.)	

<i>Spirifer cf. bisulcatus</i> Sowerby	<i>Cardiomorpha</i> sp.
<i>Spirifer striatus</i> Sowerby	<i>Ptychomphalus culleni</i> Dun & Benson
<i>Spirifer striatus</i> var. <i>attenuatus</i>	<i>Mourlonia ornata</i> Dun & Benson
<i>Reticularia lineata</i> Martin	<i>Straparallus davidis</i> Dun & Benson
<i>Reticularia</i> sp.	<i>Phanerotrema burindia</i> Dun & Benson
<i>Spathella</i> sp.	<i>Macrocheilus cf. filusus</i> Sow.
<i>Aviculopecten cf. knockonniensis</i> McCoy	<i>Loxonema</i> sp. (not <i>babbindoonensis</i> )
<i>Aviculopecten</i> (?) <i>granosus</i> de Kon.	<i>Protocantites cf. lyoni</i> M. & W.
<i>Cardiopsis cf. radiata</i> M. & W.	<i>Glyphioceras (Beyrichoceras)</i> (?)
<i>Nuculana</i> sp.	<i>Goniatite</i> (?)
<i>Grammysia</i> (?) sp.	

Most of the species have a relatively wide range within the Lower Carboniferous, but three forms are closely comparable, if not identical with *Zaphrentis cliffordana* Edwards and Haime, *Cardiopsis radiata* Meek and Worthen and *Protocantites lyoni* Meek and Worthen respectively, all of which occur in the Kinderhook Beds of the Lower Mississippian of North America (Grabau and Shimer, 1909; Worthen, 1866, p. 166). *Protocantites lyoni* also occurs in the basal beds of the Lower Carboniferous of Europe (H. Schmidt, 1923).

The faunal assemblage thus indicates that beds equivalent to the Tournaisian occur within the Burindi Series, but as yet there is insufficient evidence for more exact correlation. A careful study of the Productids and Spirifers may throw some light on the subject. Well preserved specimens of a Spirifer show some resemblances to *Spirifer (Choristites) mosquensis* Fischer de Waldheim, although direct comparison with available specimens of this Middle Carboniferous form from Moscow shows minor differences in ornamentation.

A third fossiliferous horizon occurring high in the Lower Burindi Series, near Currabubula, was described by W. N. Benson, who recorded the following forms (1920, p. 293):

<i>Zaphrentis culleni</i> Eth. fl.	<i>Productus longispinus</i> Sow.
<i>Zaphrentis</i> sp. indet.	<i>Chonetes cf. hardrensis</i> Phill.
<i>Cactocrinus brownei</i> Dun & Benson	<i>Dielasma sacculum</i> var. <i>hastata</i> Sow.
<i>Fenestella</i> sp. indet.	<i>Spirifer bisulcatus</i> Sowerby
<i>Orthis (Rhipidomella) australis</i> McCoy	<i>Spirifer</i> sp. indet.
<i>Orthis (Schizophoria) resupinata</i>	<i>Spiriferina insculpta</i> Phill.
Martin	<i>Pelecypods</i> spp. indet.
<i>Orthotetes (Schellwienella) crenistria</i>	<i>Conularia</i> sp.
Phill.	<i>Phillipsia</i> sp.

Another fossiliferous horizon in the "Merlewood" section is that of the limestone near the top of the Lower Kuttung, from which *Amygdalophyllum etheridgei* Dun and Benson was first obtained by Mrs. Scott (Benson, 1920, p. 341). It outcrops in Portion 60, in the north-east of the Parish of Babbinsboon. Tentative determinations are as follow:

(?) <i>Symplectophyllum mutatum</i> Hill	<i>Syringopora syrinx</i> Eth. fl.
<i>Amygdalophyllum etheridgei</i> D. & B.	<i>Michellinia</i> sp. (cf. <i>M. dendroides</i> Hill)
<i>Amygdalophyllum inopinatum</i> Eth. fl.	Stromatoporoid
<i>Amygdalophyllum</i> , sp. nov.	<i>Fenestella</i> sp.
<i>Aphrophyllum foliaceum</i> Hill	<i>Productus</i> (?) <i>semireticulatus</i>
<i>Aphrophyllum</i> , sp. nov.	<i>Spirifer cf. mosquensis</i> F. de W.
<i>Lithostrotion columnare</i> Eth. fl.	<i>Spirifer duplicicostatus</i> Phill.
<i>Lithostrotion stanvellenae</i> Eth. fl.	<i>Spiriferina</i> (?)

*Camarophoria* (?)

Capulid (?)

*Reticularia lineata* Martin

Pleurotemarid (?)

*Reticularia* sp.

The corals are preserved much better than the other forms and also give more definite indication of geological horizon. *Lithostrotion columnare* Eth. fl. is present in greatest abundance, although *Amygdalophyllum etheridgei* Dun and Benson is the only rugose coral previously recorded from this limestone horizon. Elsewhere in New South Wales there are occurrences of Lower Carboniferous corals within the Burindi Series. *Lithostrotion columnare* occurs at the Horton River and at Taree; *Lithostrotion stanwellense* occurs at Taree and at Hall's Creek, 16 miles south of Bingara, where the genotype of *Aphrophyllum* (*A. hallense* Smith) was found. Other species of *Aphrophyllum* occur at Babbinsboon.

Nearly all of the corals recorded by Etheridge (1900, pp. 5-24) from Lion Creek, Stanwell, Queensland, as well as several additional forms described by Dr. Dorothy Hill (1934) from the Riverleigh Limestone near Mundubberah, Queensland, are represented in the Babbinsboon limestones; in addition, there are possibly several new species.

This strongly suggests the direct correlation of the Babbinsboon and Queensland horizons. Concerning the age of the Queensland occurrences Dr. Hill states (p. 105): "The whole fauna is thus undoubtedly Upper Viséan or D in type, while *O. (Orionastraea) lonsdaleoides* and *A. (Aulina) simplex* indicate that it may be more minutely placed as homotaxial with D<sub>1</sub>."

The corals therefore indicate that the Lower Kuttung beds of Babbinsboon are Viséan in age, belonging to the Upper part of the Lower Carboniferous.

#### C. SUMMARY OF FOSSIL PLANTS.

Fossil plants are fairly common on certain horizons in the Werrie Basin.

The Upper Devonian Barraba Series contains only *Lepidodendron australe* McCoy: this does not appear in the overlying Carboniferous beds.

The flora of the Carboniferous rocks is as follows:

- (1) *Lower Burindi Series*: *Lepidodendron Veltheimianum* Sternberg, *Stigmaria ficoides*.
- (2) *Lower Kuttung Series*: *Lepidodendron Veltheimianum* Sternberg, *Stigmaria ficoides*, *Pitys* sp., undescribed plants from below the main andesite on the "Woodlands" section, including *Rhodea* (?), *Sphenopteridium* (?), *Sphenopteris* (?), etc.
- (3) *Upper Kuttung Series*.
  - (a) *Lower Glacial Stage*: *Rhacopteris intermedia* Feistmantel, *Aneimites ovata* McCoy, (?) *Calamites*, *Samaropsis* (?) *ovalis* Walkom 1935, *Samaropsis* cf. *barcellosa* White.
  - (b) *Interglacial Stage*: *Rhacopteris*, *Cordaites*, *Archaeocalamites*, *Trigonocarpus* (?) *ovoideus* Walkom 1935.
  - (c) *Upper Glacial Stage*: *Rhacopteris* spp., *Samaropsis* *Mülleri* (Feistmantel), *Carpolithus striatus* Walkom 1935, *Cordaitocarpus prolatus* Walkom 1935, *Trigonocarpus* (?) *ellipticus* Walkom 1935, *Rhacophyllum*, *Rhacopteris intermedia* Feistmantel, *R.* (?) *Roemeri* Feistmantel.

The *Lepidodendron* flora is thus confined to the Lower Carboniferous rocks, while the Middle Carboniferous Upper Kuttung Series is characterized by the *Rhacopteris* flora.



## 1. CORRELATION OF SECTIONS.

The Burindi sequence has been studied in detail only in the Merlewood area, so little can be added here. The most significant feature of this section is the finding of a rich fauna including an index Tournaisian fossil on a horizon about 700 feet above the base of the series. The only marker horizons which have been used in the field are the basal conglomerate (2)\* and the oolitic limestone horizon (3a). The former is persistent on the western side of the Werrie syncline, but has not been looked for nor found on the eastern side. The oolite horizon has been found in widely separated parts of this area and is an important local horizon-marker, seeing that it occurs among a thick series of marine muds.

\* Numbers refer to the correlation table (Text-fig. 3).



General conceptions of the origin of oolites suggest that this horizon may possibly have a wide application as an indicator.

The basal conglomerate (4) of the Lower Kuttung Series is not persistent. It is prominent in the Merlewood area, and a conglomerate already referred to north of the Woodlands section is probably also on this horizon. A pyroxene-andesite flow is associated with these conglomerates in the Merlewood area, but it has no great areal extent.

The Lower Kuttung is composed of three essential elements:

(a) Pyroxene-andesite flows, of which there are three—a very important horizon (7), the discontinuous Durl Peak horizon (10), and a horizon of very limited range (in 4).

(b) General thick masses of very coarse boulder-beds, particularly horizons (4), (6), (8), and possibly (11), but also occurring in group (9).

(c) Considerable thicknesses of buff to salmon-coloured pebbly and gritty felspathic tuff. These strata are represented by (5) and (9) in the section.

This combination is typical of the Lower Kuttung throughout the Werrie Basin. It is also typical of the Lower Kuttung (Basal and Volcanic stages) of the Hunter Valley, but there rapidly increasing thicknesses of lavas mask and ultimately almost completely replace these units.

A fourth element of the utmost importance is introduced with the Merlewood section, namely, the *Amygdalophyllum-Lithostrotion* marine horizon (9a), for this occurrence places in our hands the solution of many difficulties.

Several problems of general application arise from the analysis of the Lower Kuttung sequence. Of these, the question of the extent of the marine deposition in the Lower Kuttung, and of the Lower Carboniferous climate, and the problem of the origin and significance of the Lower Kuttung boulder beds, are all discussed in later sections of this paper.

The basal conglomerate of the Upper Kuttung Series (11) is a horizon of great interest, not only on account of the unusual size of the boulders which sometimes are found in it, but also on account of its great persistence. It has been traced for more than 50 miles in the Werrie Basin, and it is only in the Merlewood area, which is abnormal in other features, that it fails to outcrop. Moreover, it appears to be identical in lithology and horizon with the coarse basal conglomerate of the Glacial Stage described from the Hunter Valley by Osborne (1922, p. 180; 1927, p. 99; 1928, p. 575), and by Browne (1926, p. 226), and also referred to by Sussmilch and David (1931, p. 490).

During the field-work this bed has been called the Porphyry Boulder Horizon, on account of the persistent occurrence there of large rounded boulders of pink porphyry. As a matter of fact, the largest boulders are quite often not porphyry but granite; indeed, in portion 250 in the Parish of Coeypolly, boulders as large as nine feet across are visible *in situ*, and one boulder which has been disrupted by weathering appears to have been twenty feet across. It might easily be mistaken for a "pop" of granite. The outcrop is about ten yards in diameter and consists of granite blocks, some of which are about seven feet across. None of the blocks is at all rounded and it can be seen how they originally fitted together before having been disrupted along joint-planes. Another excellent exposure occurs on Werrie's Creek north of portion 176 and in portion 152 in the Parish of Werrie. Here the conglomerate is very thick and boulders more than three feet in diameter are quite numerous. The granite boulders attain the greatest dimensions, but they are not so persistent as the porphyry which seldom fails to outcrop.

Although this important conglomerate has been described as the basal bed of the Upper Kuttung, it has many features in common with the conglomerates of the Lower Kuttung. Its boulder content is essentially similar, and it is usually separated from the first obviously glacial beds in the form of varves or fluviotill by a thickness of felspathic tuff not unlike the characteristic tuffs of the Lower Kuttung. The frequent occurrence in it of silicified fragments of *Pitys* also links it with the earlier rather than with the later sediments. However, the great persistence of this formation, and the unusually large size of its boulders, justify its being regarded as the basal bed of the Upper Kuttung.

The Upper Kuttung Series admits of classification into three stages, viz., the Lower Glacial beds, the Interglacial beds and the Upper Glacial beds. The Lower Glacials have a fairly well-defined sequence. Overlying the basal conglomerate is a series of pebbly and gritty tuffs (12), which become more conglomeratic upwards. About 200 feet above the base these merge into the glacial strata (13). In the Merlewood and Royston sections only varves are developed, but in the eastern limb this glacial stage is thicker, and both varves and tillite are present. These are separated from the next glacial stage by tuffs (14). In the Woodlands and Turi Valley sections these tuffs have rather a characteristic lithology. They are well-bedded and brightly coloured in reds and greens and are probably rather acid. The next glacial horizon is so distinctive that it can be recognized immediately in any part of the area, for in all four sections this zone possesses a bed of conglomerate (15) rich in pebbles of indurated argillite which are beautifully striated and ice-scored. It is particularly thick in the Turi Valley section, but in Woodlands section it is more cemented and forms a physiographic feature.

Associated with this striated pebble horizon it is not uncommon to find a thin flow of hornblende-andesite (15a). It was encountered on the Turi Valley section, and has been traced for a little more than a mile on either side of that section. It is not developed in the Woodlands section, but was found in the hills about a mile and a half south-west of "Woodlands" homestead, and was traced for a mile along its strike before it disappeared. The same hornblende-andesite horizon reappears in the extreme northern part of the Upper Kuttung outcrop, but here again the flow only persists for about a mile and a half. It outcrops prominently in portions 25, 35, 74 and 73 in the Parish of Piallaway, about two miles north-east of Piallaway Station.\* Here it is associated as usual with the striated pebble beds, which lead up through a glacial zone to the cliffs of conglomerate and soda-rhyolite tuff of the Interglacial Stage.

To return to the general section, the striated pebble zone is followed by varves (16) which complete the Lower Glacial Stage. On the western limb of the syncline, these varves are replaced by tillite.

The Interglacial Stage is essentially tuffaceous, without definite evidence of glacial action. *Rhacopteris*-bearing strata are always included, and normal conglomerates and grits are usually present. The most characteristic element is the soda-rhyolite tuff (18), which has a quite distinctive lithology. It is missing from the Turi Valley section, but may have been cut out by a fault, the field-evidence being rather doubtful on this point. The upper part of the stage (19) is similar in all the sections, consisting of pebbly grit, thin-bedded conglomerates and white hard grits and fine sandstones which always yield *Rhacopteris* and its

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\* On the geological map of the Werrie Basin (Carey, 1934) the distinctive pattern of the hornblende-andesite was accidentally omitted from this outcrop, which appears as a line of blank lenses.

associates. These beds are highly siliceous and feldspathic, and probably represent redistributed tuffs.

The Upper Glacial Stage usually commences with a thin bouldery bed of conglomerate (20). The pebbles are hard and well-rounded and upwards of six inches in diameter. This horizon is characteristic of the eastern limb of the syncline but has not been found on the western limb.

The sequence within the Upper Glacial Stage is not so clear-cut as in the Lower Glacial beds.

Complexity was introduced into the sedimentary record of this phase owing to the simultaneous operation of several processes. Explosive volcanoes discharged vast showers of volcanic debris on to the surfaces of glaciers and into the glacial lakes, so that varve and till grade by insensible stages into tuffs and breccias. Acid lavas, too, pass imperceptibly into flow-breccias and tuffs. Lavas were poured over detrital debris, forming the matrix of volcanic conglomerates, the pebbles of which were frequently a similar lava from an earlier flow. As these lava-conglomerates are usually fairly tuffaceous, nomenclature becomes rather involved and arbitrary.

Correlation of this part of the sequence is further complicated by the fact that the western limb has thick flows of acid lava (quartz-biotite-felsite) which exceed 1,000 feet in thickness in the mountains west of Werris Creek. These are in the middle of the Upper Glacial Stage. Northwards towards Piallaway and Spring Gully, and in the central region occupied by the Quipolly dome, these lavas are represented by thinner flows separated by sediments, while in the eastern limb of the syncline they are almost entirely missing.

The upper part (25 and 26) of the Upper Glacial beds, however, is fairly constant in character. For example, the topmost conglomerate (26) is very characteristic in its occurrence throughout the area. It is not obviously glacial in its genesis and, unlike the other fluvial conglomerates in the series, its pebbles are almost entirely lavas, intraserial in origin.

A series of varves, tillites, tuffs and conglomerates always immediately underlies the top conglomerate (26). The characters of these glacial beds as they are exposed in the Woodlands and Landslide sections have already been described. The excellent exposures of this stage which have been revealed as a result of the recent constructional works at the Quipolly Dam, five miles east of Quipolly railway platform, are, to say the least of it, a glaciologist's paradise. The tillite, which is 80 feet thick, is a hard, tough rock, blue on fresh surfaces, but weathering to buff, very densely packed with chips of volcanic rocks, with a sporadic scattering of larger angular or ovoidal lava-boulders measuring up to two feet in diameter. They are frequently arranged with their longer axes upright, often dumped big end up. The rock breaks across matrix and boulders alike, and the tough matrix is more resistant to weathering than the enclosed boulders. Irregular layers and lenses of varves, often much brecciated, are scattered through the tillite; they may be masses which were torn off, incorporated in the ice-sheet, and deposited when it melted away.

So predominantly is the material which has contributed to the formation of this tillite of volcanic origin, that the first exposures were regarded as volcanic tuffs and breccias. The volcanic rocks present include such types as hornblende-andesite, pyroxene-andesite, dellenite, toscanite, felsite, albite-rhyolite, biotite-porphyrite, ophitic basalt and occasional indurated sedimentary rocks, apparently derived from a Devonian terrain forming the basement to the lava-field undergoing glaciation during this part of Kuttung time.

Above and below the tillite are varves, those beneath showing fine contortions, and those above finely-paired annual laminations. McCarthy's Creek, on the eastern side of Quipolly Dome, provides an excellent exposure of the varve-horizon immediately beneath the Quipolly Dam tillite, where the plastic material of the soft rocks has been crumpled in an extraordinary fashion.

A short distance below the varves at Quipolly Dam is an important plant-horizon which has been fruitful in its yield of fossil seeds. Several specimens of *Samaropsis Milleri* (Walkom, 1935) have been obtained from this locality as well as *Carpolithus striatus*. The same horizon has been productive of seeds of varying species at many localities in the Werrie Syncline.

## 2. SEQUENCE OF SEDIMENTATION.

### *Relation of Carboniferous to Devonian.*

There has been considerable doubt concerning the identification of the basal portion of the Carboniferous System in New South Wales. Benson (1921) discussed the question at some length, and came to the conclusion that the Burindi fauna was of Viséan age, and that, in view of the conformability of the Barraba and Burindi Series, there must be an important diastem representing the Tournaisian epoch at the junction of these two formations, or the true base of the Carboniferous must be at some unrecognizable horizon in the Barraba Series. Benson favoured the latter interpretation. Following up this statement, the present author held that if part of the Barraba be included in the Carboniferous, the base of that system should be extended down to the base of the Baldwin agglomerates, since the Baldwin-Barraba Series were a natural unit in their flora, sequence of facies, and genesis—a unit which has its base in the Baldwin agglomerates. The whole question hinged round Benson's determination of the Burindi fauna as a Viséan assemblage, a verdict which had never been questioned.

However, as the present writer's examination of the district progressed, it soon became evident that there was much confusion concerning the precise localities from which the Babbinsboon faunas had been collected, and clarity was only attained after a personal discussion with Professor Benson, and with Mrs. Scott, whose collections were included in Benson's descriptions. The writer also consulted Mr. Mackay, of "Allanbank", who as host had conducted Benson through the Babbinsboon district, and Messrs. A. H. and H. J. Perfrement, the owners of the properties concerned, who were able to say precisely what localities were visited.

The specimens of *Amygdalophyllum* described by Dun and Benson (1920) were part of a collection made by Mrs. Scott from the Merlewood Lower Kuttung limestone, but which also included some fossils from the Burindi Series near Royston. Not suspecting any marine strata in the district other than the Burindi Series, Benson recorded all these specimens as Burindi with the general locality of "south-east of Babbinsboon", although the Merlewood part of this collection is in the extreme north-east of that Parish (portion 60). The issue is further complicated by the fact that Benson made a rapid sulky reconnaissance up the valley past Royston and Merlewood to near Somerton, as the guest of Mr. Mackay, collecting on the way. The route traverses only Burindi strata and Benson recorded having obtained *Amygdalophyllum* beside the road, his specimen being figured with the description. Dr. Stanley Smith pointed out later, however, that this figured specimen was not *Amygdalophyllum* at all, but *Zaphrentis sumphuens* (Benson and Smith, 1923). The result is that there is now no authentic record of *Amygdalophyllum* from the Burindi Series of New South Wales. It should also be

pointed out that the "low hill capped with a horizontal layer of fine-grained limestone" described by Dun and Benson (*loc. cit.*, p. 289) as occurring "adjacent to portion 14 of the Parish" of Babbinsboon is really in the Parish of Somerton adjacent to Mr. Watt's homestead.

A second pertinent discovery was the recent finding by the writer of cephalopods in the lower part of the Burindi Series in the same section, which have been identified by Dr. Ida Brown as Tournaisian types.

These discoveries have filled in the gaps in the stratigraphical record so that now there is no important break in the sedimentary sequence between the Middle Devonian and the Upper Carboniferous, and the base of the Carboniferous is accurately fixed at the base of the Burindi Series.

In the field-exposures no suggestion of structural unconformity has been found between the Barraba and Burindi Series. In Swain's Gully in the Parish of Babbinsboon, the conformable contact of the two formations is exposed, and for several miles there is a continuity of outcrop of the bouldery agglomerate of the igneous zone at the top of the Barraba Series and the basal conglomerate of the Burindi Series.

#### *Lateral Variation and Overlap in the Carboniferous Sequence.*

The Burindi and Kuttung Series are conformable throughout. Although in the Lower Hunter Valley the Glacial Stage (or Upper Kuttung Series) has been found to overlap on to a granitic basement, no section has been found in the Werrie Basin where any portion has been cut out by overlap. The question arises as to the position of Osborne's Basal Stage of the Kuttung Series (the Wallarobba Conglomerates) in the Werrie Syncline section, and whether there is a diastem in the latter sequence corresponding to them.

There is no evidence to suggest that this is so. The Wallarobba Conglomerates are here interpreted as a local specially heavy development of the coarse conglomerates which are characteristic of the Lower Kuttung. Several hundred feet of the Lower Kuttung in the Werrie Basin are made up of such beds, which answer closely to the description of the size, shape and lithology of the boulders present in them at Wallarobba (see Sussmilch and David, 1919, p. 262). The facies is well within the limits of a lateral variant of a boulder-deposit of the Wallarobba type in a distance of nearly two hundred miles, even though the direction be essentially concordant with the palaeogeographical facies lines.

The origin of the conglomerates is discussed at some length in the climatic section which follows, and it is there suggested that they represent fluvio-glacial material deposited a considerable distance from the glacial front, which was well to the south-south-west. Under these circumstances it is natural to expect the heaviest development of conglomerates in the most southerly exposures, as at Wallarobba, and that two hundred miles further to the north-west there would be finer strata intercalated among the boulder beds.

A diastem of the first order may perhaps occur at the base of the Upper Kuttung. The extraordinarily large size of some of the boulders, and the remarkable persistence of the basal conglomerates have already been mentioned, and it is likely that such a feature may cover an important time-break.

The only other place within the Kuttung sequence where there is any reason to suspect a hiatus is at the base of the Upper Glacial Stage.

Lateral variation in the Carboniferous sediments has arisen from the distribution of the igneous rocks, the palaeogeography of the ice-sheets, the regional supply of materials, and differential subsidence causing thickness variation.

The first of these factors is the most obvious. In the Lower Hunter Valley there are great suites of effusives giving rise to a Volcanic Stage which is represented mainly by tuffs in the Werrie Syncline. The thick acid lavas of the western side of the Werrie Syncline are practically missing from the eastern side. The Duri Peak flow is more than 1,000 feet thick, but two miles along the strike it has cut out altogether, and so on; the examples could be multiplied.

Glacial variation is not so marked. A tillite in some of the sections is represented by varve in another and by fluvi-glacial conglomerate in a third. The glacial conglomerates are more variable than are the varves; but these variations are local, not regional. By making a large series of sections, it would be possible to delimit the boundaries of the glacial lakes in which the varves were deposited, but this has not been attempted.

Within the Werrie Basin the conglomerates seem to be coarser and thicker towards the west, but the total thicknesses of the stages to be less. This suggests that the source of the boulders lay in that direction, that the axis of geosynclinal subsidence was somewhat to the east of the axis of the present Werrie syncline, and that there was a progressive basinward thickening consistent with the subsidence. The lavas, too, thicken westwards or south-westwards and were probably extruded from that side. It is of interest to mention here that the Lower Coal Measures, which overlie the Carboniferous strata in the Werrie Basin, thicken and become coarser north-eastwards instead of south-westwards, and in the north-north-west they are overlapped against the Kuttung rocks. So it is apparent that there was a change in both the source of supply of material and in the axis of subsidence in the intervening period.

#### *Relation of Carboniferous to Kamilaroi.*

At the top of the Kuttung Series in the Werrie Basin there is an important non-sequence without angular divergence, which corresponds to the overlap of the Lower Marine Series, and in the north-west part of the region, of the Lower Coal Measures as well. This break may correspond in part to Uralian time (see Sussmilch, 1935, pp. 102-104), and in any case extends well into the Lower Permian.

#### *Extent of Marine Sedimentation in the Lower Kuttung.*

Prior to the discovery of the *Lithostrotion-Amygdalophyllum* beds among the Lower Kuttung strata of the Werrie Basin, these latter were accepted without question as a terrestrial series. Following on the discovery of the marine fossils in the Babbinsboon district, Sussmilch suggested that the upper portions of the Carboniferous marine beds in the Gloucester district, which he had previously referred to as the Burindi Series, might really be homotaxial with the Lower Kuttung (Sussmilch, 1935, p. 100). The present writer had previously made a similar suggestion with regard to the adjacent Myall Lakes area (Carey, 1934). Furthermore, the correlation of the *Amygdalophyllum* limestone of the Werrie Basin with the Lion Creek limestone of Queensland, makes it clear that some of the Queensland time-equivalents of the Lower Kuttung are marine.

Thus, in personal conversations with the writer, the question has been rather pointedly raised: Are the Lower Kuttung sediments of marine origin? It is true that *Lepidodendron Veltheimianum* and *Stigmaria ficoides*, etc., have been obtained from them; but these same fossils have been collected from the Burindi Series, where they occur cheek by jowl with a rich marine fauna. So may they not represent drift material into an estuarine sea?

This problem may be approached along more than one avenue. An analysis of the internal evidence of the marine strata of the Babbinoon district is interesting in this connexion.

The marine beds outcrop for about three miles, and in this distance there is a progressive facies change indicative of increasing depth northwards from a strand-line south-east of "Merlewood" homestead (see Plate xviii). On the Merlewood section line (the north boundary of portion 61 in the Parish of Babbinoon) the horizon is represented by 270 feet of oolitic grits and conglomerates. Oolites in general are characteristic of a very shallow-water facies and often represent beach-deposits, and an oolitic conglomerate of this type is clearly a near-strand bed. The lithology of the pebbles, consisting as they do of well-worn ellipsoids, well graded in size, shape and mechanical resistance, is obviously the result of prolonged winnowing and attrition by the waves in the shingle zone. No marine life throve in this environment. In contrast to the prolific collecting-ground northwards along the strike, several hours' search up and down the naked outcrops of this zone yielded only a single battered crinoid ossicle, which was probably transported thither by the waves. Northwards from this inshore-facies, across the north boundary of portion 3 into the western part of portion 10, the oolite zone widens, and as it does so it fingers out, becoming interdigitated with normal shallow-water marine conglomerate. This gradually increases at the expense of the oolite, and in a short space the latter has wedged out entirely. Towards the north-western sector of portion 10 the conglomerate attains its maximum development, rising to form an elevated cuesta. This portion of the deposit is best interpreted as an off-shore shingle-like conglomerate deposited in a current-zone.

The conglomerate continues through portion 26 (locally known as the "Dight 40-Acre") and through the western leg of portion 14, but it is dwindling rapidly meanwhile, and by the time the windmill on the bank of Swain's Gully in that portion is reached, there are only a few feet of gravel left to represent the bed, which could easily be passed over even by someone looking for that conglomerate horizon. For, although this environment is beyond the off-shore conglomerate zone, it has not yet reached the zone of abundant marine life. However, a short distance north of the windmill, at a small shoulder which has been called "Hill 60" after the number of the portion in which it stands, the reef-coral facies appears with surprising suddenness, with a prolific development of *Lithostrotion*, with *Amygdalophyllum*, *Syringopora* and other forms as accessories. The corals are most prolific at the southern (near-shore) end and northwards the bed rapidly tapers off, until in a couple of hundred yards it has dwindled to isolated "stringers" of limestone, which are mostly barren. This passes into a marly zone packed with thin-shelled *Mourtonia*, clearly representing a slowly deepening habitat. Nearby is a spot which has yielded a few brachiopods (*Spirifer* cf. *mosquensis*). Beyond are mudstones with occasional thin lenses of barren limestone.

The Merlewood fossiliferous horizon, then, provides a fine study in a progressive facies change in a single thin bed along three miles of strike, from an inshore shingle through the current-zone, to the coral-reef, and into the deeper waters beyond. It leaves little doubt which way the land lay. The shore was to the south—between the Merlewood and Royston sections. The latter contains no marine beds on this horizon; it is the normal section of the Lower Kuttung as it is usually developed in the Werrie Basin—a terrestrial series.

A second approach to the question of the extent of marine deposition in the Lower Kuttung is by way of the conglomerates. It does not seem feasible that the

thick boulder beds recurrent through this series were transported and distributed by the sea. They are not marginal conglomerates which change their facies in a few miles of strike. They persist for long distances, and continue around large structures, which thus introduce the second dimension of areal distribution into the problem. Their field-relations leave no doubt that they are sheet-deposits. It is admitted that sheet boulder beds of wide extent may be deposited by a steadily retreating sea. But such deposits are usually obliterated during the subsequent marine advance. (For a discussion of the environmental conditions of such conglomerates see Twenhofel, 1936, pp. 681, 682.) The Lower Kuttung examples have not the characters of marine conglomerates of this type.

Terrestrial waters are able to attain flushing volumes and velocities and with impulsive transporting power greatly in excess of the capabilities of the sea which, except along the strand line, depends on smaller forces acting for longer times to transport greater total quantities but in smaller individual masses. Although surprisingly powerful sea-floor velocities have been recorded by some investigators (Twenhofel, *loc. cit.*, pp. 686-7), marine sets and currents are never strong enough to distribute large boulder beds over wide areas.

It is interesting to compare the pebbles in the proven marine conglomerate of the same age with the normal Lower Kuttung conglomerates. In Babbinsboon, as we have seen, a littoral shingle laterally separates the oolite facies from the reef-coral facies. It occurs in an environment where the transporting power of the currents might be expected to be a maximum. The pebbles seldom exceed three inches in major diameter and have usually two nearly equal minor diameters, a form produced by and amenable to wave and current transportation. The finding of these foreign pebbles belonging to marine strata interbedded among very coarse boulder beds radically different in source, size and lithology, suggests immediately that the coarse boulders reached their destination by a terrestrial route and that the marine gravel was transported thither by a different way and by a different agency.

The fossil content of the Lower Kuttung, too, throws some light on the problem. With the exception of the *Amygdalophyllum-Lithostrotion* horizon itself, no marine fossils have been found anywhere in the series. Plant horizons are fairly numerous. Some of these could be regarded as drift material buried among marine sediment. But others, like the *Rhodca* (?) horizon in the Woodlands section, where the shale is packed with thin-pinnuled ferns, are almost certainly freshwater beds.

Moreover, the pyroxene-andesite flows show no evidence, such as pillow structure, or sub-marine zeolitization, of having been extruded on the sea-floor.

To sum up, there is much to suggest that the Lower Kuttung of the Werrie Basin is essentially a terrestrial series, with but little contrary evidence. However, the fact that a temporary invasion of the sea took place in the north-west corner of the Werrie Basin with no disturbance of the sedimentary record in adjacent areas, shows that the terrestrial strata were deposited close to sea-level.

### 3. SEQUENCE OF CLIMATES.

#### *Interpretation and Significance of Lower Kuttung Conglomerates.*

One of the problems of the Lower Kuttung is that of the origin and significance of the great thickness of coarse conglomerates which are characteristic of this Series.

It has already been pointed out that they are widespread sheet deposits of terrestrial origin, which recur again and again in the sequence. They are not



glacial conglomerates in the ordinary sense, for the boulders are well-rounded and rudely graded and bedded, and signs of glacial markings are extremely rare. In the wide region over which these beds have been examined, the only record of Lower Kuttung glaciation is contained in varve-shales and fluvio-glacial conglomerates in the Gosforth district, Lower Hunter Valley (Browne, 1926).

In considering the origin of these conglomerates it is necessary to conceive of both a source for the boulders and an aqueous agent which could repeatedly distribute such large boulders uniformly over so wide a field.

The most probable explanation seems to be that they represent sheet-apron deposits transported well out beyond a piedmont glacial front. Their wide distribution and general characters and lithology and the usual lack of any sign of glacial faceting or striation on the boulders, indicate that they were laid down beyond the zone of eskers and kames, even beyond the terrain of ordinary fluvio-glacial deposits; the contribution of the glaciers was to provide large quantities of bouldery material and the large impulsive volumes of water capable of completing the ablation to the ultimate site of deposition.

The highlands which supplied the glaciers probably lay to the south-west. The higher grade glacial deposits would be entirely removed from this region by the subsequent erosion during the rest of the Carboniferous and Permian periods. For at Gosforth and Pokolbin Upper Kuttung strata rest unconformably on a stripped granitic terrain, and further west Upper Marine and Upper Coal Measure strata are lying directly on an eroded basement of Middle Palaeozoic rocks. Thus the record of this earlier glaciation is preserved only in boulder beds which were deposited a long way from the scene, beds which were least fitted to tell the tale.

Sir Edgeworth David has compared this schotter gravel apron with the present fluvio-glacial flood-plains of Alaska (1932, p. 57). Mr. J. N. Montgomery, who spent a number of years in Persia (Iran) with the Anglo-Persian Oil Company, has suggested\* that another possible analogue to the Lower Kuttung conglomerates is to be found in the boulder-beds of the Upper Bakhtiari Series in south-west Persia. Nobody has ever suggested that these thick, coarse conglomerates are fluvio-glacial, nor have any ice-scratched boulders been recorded from them. They are probably Pleistocene in age, and may represent the ultimate terrestrial outwash from a big glacial front in the Zagros Mountains and the Central Persian Plateau, which would almost certainly be glaciated at this time in view of the fact that the Lebanon Mountains adjacent to the Mediterranean were heavily glaciated, and that the ice reached down to 4,500 feet in latitude 26 degrees in Bengal, and to 2,000 or 3,000 feet in the Western Himalayas (Coleman, 1908, p. 348). The extent and thickness of the Bakhtiari conglomerates and their general characters seem to be analogous to those of the Lower Kuttung conglomerates.

The significance of the interpretation of the Lower Kuttung boulder beds is that the Carboniferous refrigeration of Australia first manifested itself in Viséan time, for the faunas of the Werrie Basin have made it clear that the Burindi Series there is essentially Tournaisian, and the Lower Kuttung is Viséan. It has already been pointed out that the Lower Kuttung sedimentation took place close to sea-level. The Viséan climates were not sufficiently cold to bring the glaciers down to this sedimentary plain. Herein we have a qualitative climatic index for this portion of the Carboniferous Period.

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\* Personal discussion with the writer.

*Significance of Lithostrotion Horizon.*

The assumption of glacial connexion for the Lower Kuttung conglomerates immediately raises the question of the climatic implication of the *Lithostrotion-Amygdalophyllum* bed, which is in sufficiently close association with the conglomerates to provoke comment.

Under the doctrine of the continuity of geological processes it has been customary to assume that the presence of reef-building corals is indicative of warm (essentially tropical) seas. In view of the repeated demonstration in many parts of the geological record of the remarkable adaptability of organic life to even wide environmental changes, this assumption is not wholly justified. Palaeozoic reef-corals may have flourished in seas considerably colder than is the rule to-day. Nevertheless, it is probably fairly safe to assume that the occurrence of a reef-coral zone in a sub-glacial sequence indicates a temporary warming of the seas during an interglacial phase.

If this interpretation is correct reef-corals would only be found in the restricted zone of the temporary amelioration of climate.

Speaking of the Carboniferous faunas of Queensland, Whitehouse (1930) wrote: "At no locality has more than one limestone bed yielded reef-corals. It seems, therefore, that conditions for reef-corals in Eastern Australia during the Carboniferous were limited to a very short period." The coral horizon of Whitehouse is the Lion Creek *Amygdalophyllum-Lithostrotion* bed which is homotaxial with the similar horizon in the Werrie Basin now under discussion.

It would seem, then, that the horizon represents a lull between the sub-glacial conditions of the Lower Kuttung and the more intense refrigeration of the Upper Kuttung.

*Climatic Interpretation of the Upper Kuttung.*

Little has been done as yet towards an analysis of the glacial record preserved in the Upper Kuttung sediments, in order to reconstruct the sequence of glacial and interglacial epochs. A detailed study of this question would present interesting problems in the disentangling of the glacial from the pyroclastic suites.

It is clear from the outset that two main cold epochs are represented by the Upper and Lower Glacial Stages, and that these were separated from each other by the epoch of the Interglacial Stage, the conglomerates and grits of which are distinctly free from ice-action.

Studies of the details of the glacial rocks frequently yield clear accounts of the climatic changes which have taken place during their deposition. For example, at the Gap west of Werris Creek the gradual advance of the ice-sheet to its maximum followed by its steady waning, is faithfully recorded through seventeen hundred feet of strata, which overlie the lavas there. The lavas are followed by volcanic conglomerates composed of felsitic boulders in a matrix of fragments of the same material. The finer gritty phases are rather susceptible to chemical destruction and show typical spheroidal weathering to a rotten, green rubble. But the initial disintegration which produced these rocks in Kuttung times was dominantly mechanical rather than chemical, and savours distinctly of freezing and thawing action; this first suspicion of glacial conditions is immediately confirmed by the appearance of varves. The varves are 250 feet in thickness and towards the top there is a sudden disposition to contortions, yielding some beautiful specimens, due to the impress of overriding glaciers of an advancing ice-sheet. The varves in turn pass upwards into 300 feet of glacial grits and tillite, which represent the culmination of the glacial advance. The tillite passes

by gradual transition into another 830 feet of varves which are overlain by aqueo-glacial grits denoting a considerable retreat of the ice-sheet. The final bed of the suite is 260 feet of fluvio-glacial conglomerate, deposited a considerable distance from the ice-front. The pebbles are ill-sorted with occasional large erratics, but they are usually water-worn and no longer retain identifiable striations.

When these methods are applied to the systematic sections, it will be seen that beds (12), (13) and (14) in the Lower Glacial Stage represent a complete glacial cycle of advance, culmination and retreat. This is most clearly shown in the Woodlands section. Beds (15) and (16) record the second advance, which was not quite so severe as the first. The Interglacial Stage follows, and here the conglomerates and grits which accompany the tuffs all have the normal lithology of a water-transported sediment. This is a long interglacial break. In the Upper Glacial Stage there are two short glacial epochs, represented by beds (21) and (23), which are separated by an interglacial group of sediments, and a culminating prolonged advance (25) recorded by the spectacular glacial deposits of Quipolly Dam, McCarthy's Creek, and the Gap near Werris Creek, the last of which has just been described.

To recapitulate, the internal evidence of the Upper Kuttung of the Werris Basin indicates two successive glacial advances followed by an important interglacial break, then two short glacial advances followed by a final prolonged refrigeration, which completed the Kuttung cycle (see Text-fig. 4).

#### *Climatic Evidence of the Tuffs.*

In the Werris Basin Upper Kuttung can usually be distinguished immediately from Lower Kuttung tuff on its lithology alone,\* and there is at least a suspicion that climatic conditions may have contributed to this as much as, or more than, chemical or petrological differences.

The tuffs interbedded with the glacial stages are often as hard as the lavas from which they are derived. Colours are bright in reds, greens, blues, greys and browns, much like lithoidal lava groundmasses. This material often shows evidence of magmatic weathering prior to ejection (with the generation of haematite, albite, chlorite, etc.), but no pre-depositional subaërial weathering, or weathering by connate waters. An excellent example is the Gap volcanic conglomerate already quoted (p. 365). Such tuffs are not found in the Lower Kuttung where depositional weathering is the rule.

In the Interglacial Stage there is a considerable quantity of pebbly water-redistributed tuff, the manner of accumulation of which must have been very similar to that of the pebbly tuffs of the Lower Kuttung. The grainsize, texture, bedding, manner of sorting, and sedimentary admixture, are all very similar in both groups, and both are acid and felspathic. But those in the Lower Kuttung are invariably warm buff, brown, or salmon-pink in colour, whereas those in the Interglacial Stage are white. The former are soft and friable from pre-depositional weathering, the latter are fresh and hard. The differences are probably largely climatic.

The most probable interpretation of these observations is that the tuffs of the Lower and Upper Kuttung express an increasing grade of climatic severity.

This is a line of investigation which must not be pressed too far on the data available at present, but which might well be pursued further by later workers.

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\* This may or may not also be applicable to the Lower Hunter Valley, because there is greater complexity in the volcanic sequence in that region. (Vide p. 369.)

*The Plants as Climatic Indicators.*

As yet little has been done in the interpretation of the climatic significance of the Carboniferous floras, although ultimately they may provide one of our most valuable keys.

The silica-petrifications of *Clepsydropsis*, and of *Pitys* with well-developed annual rings, in the Lower Kuttung may be interpreted climatically after detailed palaeobotanical work.

Leaf impressions of *Cordaites*—a gymnosperm tree—occur in the Interglacial Stage in the Werrie Basin.

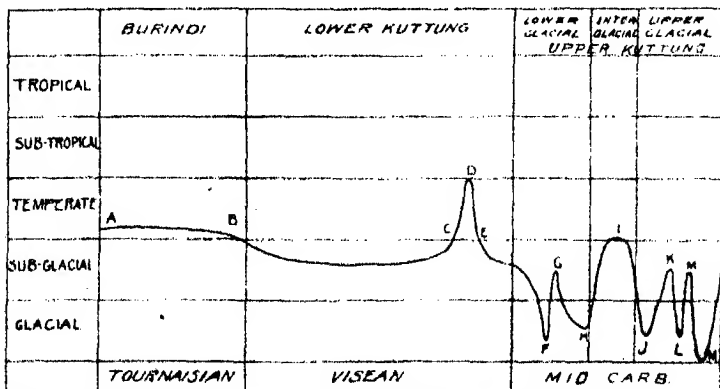
So far as the writer's observations go, the *Rhacopteris* flora is associated with the warmer theses (see Huntington, 1907, p. 362) between the periods of glacial advance. Thus *Rhacopteris* is always well developed in the finer beds of the Interglacial Stage, deposited during the most important interglacial epoch of the whole glacial strophe; and, where *Rhacopteris* is present in the glacial stages, the beds which actually carry the flora usually have a lithology similar to the plant-beds of the Interglacial Stage, often with pebbly and gritty bands with a non-glacial appearance, although they are interbedded with varves and tillite. Browne has recorded *Rhacopteris* from varves in the Gosforth section (1926), but in the writer's experience such occurrences are very rare.

Much may result from a detailed investigation of the Pteridosperm group, and the assigning of vegetative organs to the many fossil seeds which have been found in the Upper Kuttung of the Werrie Basin, and an ultimate interpretation of the life-cycle of those plants and the conditions governing the ripening of their fruits. Petrifications of this material are highly desirable.

*Reconstruction of the Climatic Sequence.*

The problem of the Carboniferous climate has now been approached along various independent lines of inquiry. The results of these investigations have been co-ordinated and expressed qualitatively as a graph of climate against time (Text-fig. 4).

In this diagram the section between A and B expresses the environment of the Burindi Series. The preceding Devonian Period had been warm and arid, as indicated by the extensive coral-reefs of the Mid-Devonian, and the succeeding red beds of the Lower Drummond and Dotswood formations of Queensland and else-



Text-fig. 4.—Climatic Sequence in the Carboniferous Rocks of the Werrie Basin.

where (Reid, 1930, p. 221; David, 1932, p. 48). The Burindi sediments contain no suspicion of ice-action and the fauna is one which is typical of temperate rather than tropical seas. Although the depth oscillated between a shallow oolitic facies and a deeper mudstone facies beyond the brachiopod zone, there is no authentic record of reef-coral. In the highest fossiliferous horizon of the Burindi Series in the Woodlands section, the forms are conspicuously dwarfed, a fact which may reflect the incipient refrigeration of the coming glacial epoch (David, 1932, p. 59).

The sub-glacial condition indicated between B and C is based on the interpretation of the Lower Kuttung conglomerates as outlined in the foregoing remarks. This part of the curve should probably be more oscillatory than is indicated. It may eventually be possible, by correlating the successive boulder horizons with advances and retreats of the distant ice-sheet, to make the curve more complete. It may also be possible to approach the problem by a careful study of the facies of the faunas of the Upper Rockhampton Series in Queensland, for there a complete marine faunal record is available for the section between B and C.

The warm interglacial epoch marked by the curve CDE is recorded by the restricted reef-coral zone of the *Amygdalophyllum-Lithostrotion* horizon. The height of the apex of the curve at this point is rather arbitrary. It almost certainly extended well into the temperate zone, and perhaps even into the sub-tropical.

The succession of glacial advances and retreats between E and O is exactly in accord with the internal evidence of the glacial strata as outlined in the preceding remarks. The curve GHI is steeper on the right hand side because the retreat of the ice-sheet was apparently very rapid and left little to represent it, whereas in the glacial advance recorded by MNO both advance and retreat are outlined through a thick series of strata, so the curve is more symmetrical. The most intense glaciations occurred at F and N, and the most prolonged interglacial epoch at J in the Interglacial Stage.

Each of the glacial advances contains considerable thicknesses of varves, which should lend themselves to analysis according to the principles of the school founded by Baron De Geer.

The graph which has been constructed is meant to be regarded as a qualitative first approximation, and its shortcomings must not be overlooked. For example, there are fundamental principles of stratigraphy which cannot be set aside. Whole glacial cycles may be obliterated by subsequent advances, leaving scarcely a recognizable diastem, and Barrell's law, that the rate of sedimentation is a direct function of the rate of subsidence, is partly applicable if it is stated in the more generalized form, that sediments will not continue to accumulate in an environment where rate of removal equals or exceeds rate of supply.

However, in spite of these drawbacks, it is hoped that the graph may be of value as a first attempt to depict the Carboniferous climatic sequence, and as a foundation for further research.

It is of interest to compare this curve, which has been derived solely by plotting the internal evidence of the sediments, with general conceptions of the behaviour of climatic cycles (see figure in Huntington, 1907, p. 362). If the Carboniferous climatic curve be extended back to the warm conditions of the Devonian red beds and reef-corals, and forward through the waning glacial conditions of the Kamilaroi (Sussmilch and David, 1931, table facing p. 514), it will be seen that the Devonian and Lower Carboniferous correspond to one of Huntington's interstrophes. The glacial strophe reaches its acme in the Upper

Glacial beds, diminishes again through the Lower Kamilaroi, and is completed with the Bolwarra Conglomerate. An important thesial epoch equivalent to the Interglacial Stage, but on the other side of the acme, is represented by the Lower Coal Measures. To judge by the Upper Permian insect fauna (David, 1932, p. 68), it was well into the Triassic before the climate fully recovered from the effects of this great ice-age.

#### 4. SEQUENCE OF VOLCANISM.

The development of volcanic products in the Kuttung Series of the Hunter Valley has received a good deal of attention, particularly in the writings of Osborne (1922, 1925, 1926, 1929), Browne (1926, 1929), and Sussmilch (1928, 1935). So impressive are the lavas there that Osborne designated the upper part of the Lower Kuttung the Volcanic Stage, and successfully used indicator lavas as markers (the Martin's Creek andesite and the Paterson toscanite, etc.) for some of his subdivisions of the Kuttung sequence.

In the Werrie Basin there is also an extensive development of lavas, but, apart from the pyroxene-andesites, which seem to have maintained a remarkable persistence of horizon throughout, the incidence of the various lava-types in the stratigraphical column is not the same as in the Hunter Valley.

#### *Distribution in Time.*

There are no proven lavas in the Burindi Series of the Werrie Basin, and tuffs play a very minor part.

The flows of the Lower Kuttung are almost exclusively pyroxene-andesites, which attain great thickness. They are developed on two principal horizons—the main horizon nearly 2,000 feet above the base of the Lower Kuttung and about 3,000 feet from the top of that series, and the discontinuous horizon of Duri Peak at the top of the Lower Kuttung. In the Merlewood area this horizon is underlain by a locally important horizon of biotite-felsite, and followed by another thin felsite. These are the only extrusive representatives of the thick suite of acid and intermediate lavas of the Volcanic Stage of the Hunter Valley.

The Lower Glacial beds are frequently without lavas, and, so far as the Werrie Basin is concerned, these are confined to hornblende-andesites, the flows of which are developed in several places in association with the striated pebble horizon (15).

On the divide between Jacob and Joseph Creek and Coeypolly Creek there is a thin local flow of hornblende-andesite at the base of the Upper Kuttung, which may be on the horizon of the hornblende-andesite of the Mid-Hunter Valley.

The Interglacial Stage, too, is usually free from lavas, but the soda-rhyolite tuffs (18) which are characteristic of this stage grade locally into a tuffaceous flow, as for example in portion 25 in the Parish of Piallaway.

Apart from the hornblende-andesite at the Gap west of Werrie Creek, the Upper Glacial beds have only acid lavas—mainly felsitic types with large phenocrysts of quartz and biotite. These occur about in the middle of the Upper Glacial Stage, where they attain great thicknesses on a horizon which appears to be slightly higher than that of the Paterson toscanite of Osborne. Owing to the complexity of the structure, caution is necessary in discussing the horizon of the Gap hornblende-andesite, but it is probably to be placed between horizons (24) and (25) of the generalized table (Text-fig. 3).

On a review of the sequence of lavas in the Werrie Basin it is seen that the Lower Kuttung is characterized by thick pyroxene-andesites, the lower glacials by thin hornblende-andesites, and the upper glacials by thick acid lavas with some

hornblende-andesite. So far as this restricted region is concerned, the order of extrusion is simply one of increasing acidity.

Explosive activity was practically continuous throughout Kuttung time. The tuffs are uniformly acid, but the acidity and alkalinity seem, so far as one can judge by their lithology, more marked in the Upper than in the Lower Kuttung.

#### *Distribution in Area.*

The distribution of the pyroxene-andesites in the Werrie Basin is shown in the map already published (Carey, 1934). There are three horizons—a restricted zone of sills in the Burindi Series, the main flow horizon in the Lower Kuttung Series and the Duri Peak horizon at the top of the Lower Kuttung Series.

The Duri Peak horizon is discontinuous in outcrop and its thickness is subject to rapid variation. The main flow, on the other hand, is very persistent and is usually several hundred feet thick.

From the point where it is cut off by the thrust near Piallaway the main pyroxene-andesite is traceable in a northerly direction for six miles before it thins out. It reappears on the eastern limb of the syncline, and southwards maintains an unbroken outcrop and physiographic prominence for thirty miles until the limit of the map is reached. It attains its greatest known development near Gaspard Mountain, where it passes out of the mapped area, trending towards the Liverpool Range.

On comparing the eastern and western limbs it is seen that on both sides the andesites thin out towards the north, but that they extend further up the west flank than the east. A study of the map suggests that the greatest thickness is to be expected in a west-south-west direction. Unfortunately the outcrop of the Lower Kuttung in this direction is cut off by the Mooki Thrust system, and by the regional plunge westwards off the New England geanticline.

The widely scattered thin flows of hornblende-andesite contribute little information, but the extensive acid lavas of the Upper Glacial beds confirm the suggestion given by the pyroxene-andesites. These lavas attain their maximum development in their most western exposure. In the Quirindi dome west of Werris Creek the acid flows attain a thickness of considerably more than a thousand feet. Four miles east from here in the Quipolly dome these thick extrusives have been reduced to thin flows separated by sediments; the eastward thinning is apparent on the two sides of the dome. A similar state of affairs is found in the Castle Mountain Dome. Two miles further east, where the general horizon reappears in the eastern limb, only rare thin stringers are left to represent them.

Thus the distribution of the lavas, both acid and andesitic, points to the conclusion that they were extruded from the west, rather than from the east.

#### *Extrusive Character of the Andesites.*

In 1920 Dr. W. N. Benson, discussing the geology of the Currabubula district, reported the occurrence of three horizons of more or less glassy pyroxene-andesite. These he considers to be intrusive sills, although he points out that "no indubitable evidence of the intrusive nature of the main zone of pyroxene-andesite has yet been found, and its classification rests chiefly on the lithological similarity with the rock of the eastern zone" where definite evidence of intrusion is found.

This determination of the Currabubula andesites as sills, although tentative, has led to many doubts in later literature. For example, Osborne (1922, p. 164), referring to the pyroxene-andesites of the Paterson district, wrote: "Thus the only horizons about which any doubt remains are the more basic and those which else-

where in the State appear to be sometimes definitely intrusive and which, in the area under consideration, are not accompanied by tufts of similar composition." In a subsequent paper (1925, p. 113), Osborne describes the Clarencetown andesites as flows.

Later, Professor Browne (1929, p. xxviii), in his review of the Palaeozoic igneous activity of New South Wales, again refers to this matter: "We do not yet know, for example, and only detailed field-work can tell us, why it is that in the southern areas the andesitic magma made its way to the surface, whereas in the more northern parts as at Currabubula, sill-intrusions and dykes appear to be the rule, though further to the north-west andesite flows are interbedded with the Kuttung conglomerates."

Since these papers appeared the present author has examined the andesites throughout the Werrie Basin, of which the Currabubula district forms a part, and has found abundant evidence that, although those pyroxene-andesites which occur within the Burindi Series are undeniably intrusive, as Benson has shown (1920, p. 293), those which occur in the Kuttung Series are flows. The following field-observations support this conclusion:

The main pyroxene-andesite has been examined along forty miles of outcrop, and at no point in that distance has any evidence of contact-metamorphism or transgression been observed at its upper surface. Typically the top of the flow makes poor outcrop. This is due both to contemporaneous weathering of the andesite and to the absence of any contact hardening in the overlying sediments.

In portion 180, Parish of Evan, near the head of Currabubula Creek, fine tuffaceous shales may be seen overlying the eroded and deeply weathered surface of the flow. A similar exposure occurs on the bank of Currabubula Creek near "Woodlands" homestead. A leached kaolinitic zone was found above the andesite in portion 104, Parish of Currabubula.

Tuff-breccias are developed at the upper surface in many places. Thus in a small gully in portion 258 in the Parish of Currabubula angular blocks of coarse andesite are embedded in a mixture of finer-grained lava and andesitic tuff. In Gaspard Creek near Wallabadah, where the andesite is well developed, it seems to be composed of one thick initial intrusion followed by a series of thin flows which pass into flow-breccias. Similar evidence has been seen in all the masses of the higher andesite horizon, e.g., in portion 247, Parish of Werrie, in the Kingsmill's Peak mass. Associated with the tuff-breccia there are occasional amygdaloidal and scoriaceous phases; these features are most marked where the flow is thin, as in the tongue where the Duri Peak mass is wedging out. In a sill a thin extremity of this kind, instead of being scoriaceous and amygdaloidal with abundant cavities, would be very fine-grained and compact. Also where vesicular phases are developed, they are found at the upper surface, not in the middle as they would be in the case of a sill.

Fluxional banding with development of spherulites is quite a common feature on both horizons. Pebbles of pyroxene-andesite occur in some of the Lower Kuttung conglomerates.

The important factor which led Professor Benson to regard the andesite as intrusive was its lithological resemblance to the proved sills in the Burindi Series. However, apart from the similarity of rock-type, there is considerable divergence of characters in the field. Evidence of contact-metamorphism is quite common above the sills, and where their outcrop wedges out the line is carried on for long distances by zones of silicification and quartz reefs, indicating that the intrusion persists at a shallow depth. Furthermore, when the sills are carefully



mapped, it is found that their horizon in the Burindi Series is not constant and in places they are markedly transgressive. The flows in the Kuttung Series on the other hand are persistent in their horizons, and never transgressive.

In view of all the field-facts, the extrusive character of the Kuttung andesites of the Werrie Basin is placed beyond question, and this region is brought into harmony with the other parts of the State.

#### *Relation of Lithoidal and Glassy Andesites.*

The relation of the stony and glassy phases of the Kuttung andesites has been the subject of some discussion (see Osborne, 1925, pp. 116-119). Professor Browne, in his survey of Palaeozoic igneous action in New South Wales (1929, p. xxviii) wrote: "Another matter that has yet to be cleared up is the relationship of the glassy and stony types of andesite. Some lines of evidence tend to show that they are separate and distinct phases, while on other grounds it would appear that devitrification or some such process has been responsible for the conversion of glassy into stony types."

In this connection the field-relations of the two phases in the Werrie Basin suggest that the glassy andesite merely represents the rapidly-cooled portion of the flow. The base of the flow is usually glassy and prismatic; this passes up into a banded zone, where there is an interlamination of the vitrophyric and lithoidal phases. The bands vary in thickness from a fraction of an inch to a foot or more. Such types may be seen at many places along the scarps of the andesite cuesta-line north-east of Currabubula. The lamination may have been caused by the mixing and streaking out of the hotter and cooler parts of the magma during extrusion. Near the centre of the mass there would be sufficient time for the equalization of the heat before solidification, but at the margins the rapid congelation of the already cooled layers would form glass, while the hotter layers would show rudimentary crystallization.

Similar banding is found also at the top of the flow, where fluxional contortions are common in the banded rock.

A variant of this phase is found on the upper surface of the Duri Peak flow, where selective bands are packed with small spherulites up to an inch in diameter. On the Royston section the upper surface of the main andesite shows numerous large spherulites of the lithoidal phase embedded in the glassy andesite. Similar spherulitic structures are to be seen in the bed of Werrie's Creek in portion 172, Parish of Werrie.

On the interpretation outlined here, the stony phases were cryptocrystalline *ab initio* and are not, as a general rule, a product of the devitrification of the glassy phases. This view, based on field-evidence, is in agreement with the results of Osborne's microscopic analysis (1925, p. 118).

#### 5. SEQUENCE OF PHYSIOGRAPHIC EXPRESSION.

The Werrie Basin is a region in which topography has been able to adjust itself more or less completely to rock structure. Differential erosion has attained equilibrium and there is scarcely a hill whose form is not obviously due to its local geological association. The Werrie basalts, the softest strata, have everywhere reached their base-level and form open plains between the mountains and ridges of the Upper Kuttung and Warrigundi rocks. Other soft groups such as the Burindi and Barraba beds and the Lower Kuttung tuffs approximate perfectly to this peneplaned condition, and form long strike-valleys.

Each stratum then, has a physiographic index which depends partly on its own resistance to chemical and mechanical disintegration and partly on its association in the sequence with other weak or strong beds which will expose it to or protect it from the agents of denudation.

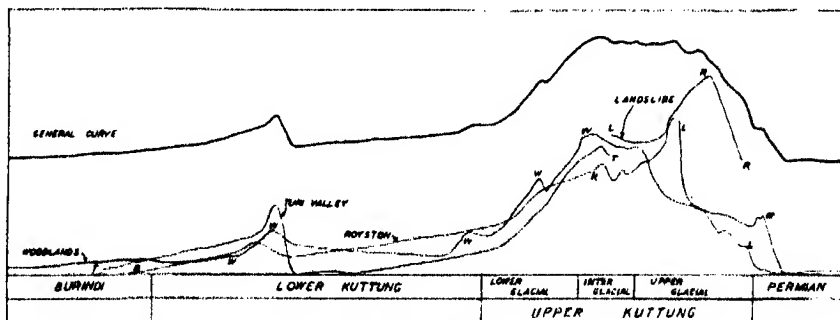
A set of graphs (Text-fig. 5) has been constructed to illustrate the sequence of physiographic expression in the Werrie Basin. A profile-graph has been drawn for each of the stratigraphical sections, using the average thickness of each bed as abscissa and twice the elevation of the outcrop of that particular bed on the section-line as ordinate. In each case the datum from which the elevation was measured was the lowest point on the section. It was necessary to use the average thickness of the bed in order that the profiles might be directly compared. The resulting graph is equivalent to the profile which the beds would give if they were dipping vertically.

The general similarity of all the curves is at once apparent. The plain of the Werrie basalts, the lowlands of the Lower Kuttung and Burindi Series, and the mountain range of the Upper Kuttung are common to all the graphs.

They are not precisely similar, however. They are similar only in so far as their stratigraphical sequence is similar, for the differences between the curves are directly related to lateral variations in the sequence.

Thus the differences on horizons (6) and (7) are due to variations in the thickness of the pyroxene-andesite flow and the boulder beds beneath it. The Turi Valley section is the nearest approach to the average for the Werrie Basin for this horizon.

The crest on the Woodlands curve at horizon (10) is due to the development there of the upper zone of pyroxene-andesite. Duri Peak or Kingsmill Peak sections would show lofty cuestas at this point. The trough on the same section, however, above horizon (14) is due merely to the way the section cut the local drainage; a line a little to the south of the section would have avoided this gully. Sufficient numbers of sections would eliminate all such local irregularities from the general curve compounded from them.



Text-fig. 5.—Sequence of Physiographical Expression in the Werrie Basin.

The high eminence developed on the Royston curve at horizon (24) is due solely to the great thickness of acid lava which forms the Piallaway Trig. station ridge, and which is absent from the other sections.

The Woodlands section is the only one which includes the Lower Coal Measures, which accordingly express themselves on the graph. The gradients LL and RR are normal where the Lower Coal Measures are overlapped.

The general curve was constructed by averaging the individual profiles. The ordinate for each horizon is an approximation of its physiographic index.

The conspicuous features of the general curve are the main range of the Upper Kuttung, the downs of the Lower Kuttung and Burindi, the ridge-line of the main pyroxene-andesite, and the Werrie basalt plains.

As was pointed out above, this curve represents the strata as dipping vertically. With the usual dips in the Werrie region the main pyroxene-andesite forms a beautiful line of *cuestas*. From the top of Kingsmill's Peak it is a most inspiring sight to look along this splendid row of *cuesta-tops*, extending for twenty-five miles in an unbroken line, each dressed against its neighbour, with their sweeping dip-slopes losing themselves one behind the other in the valley beneath. From the same lookout one can view the rolling lowlands of the Lower Kuttung, between the *cuesta-line* on the east and the bluff scarps of the Upper Kuttung on the west. Several divides belonging to the transverse drainage cross this valley, but never do they attain sufficient prominence to break its continuity.

With the prevailing moderate dips the Upper Kuttung forms a high double or triple *cuesta*. The lower part of the Interglacial Stage usually overhangs the Lower Glacial beds along a line of cliffs, but the upper part recedes some distance down the dip-slope, forming a longitudinal col between the crest of the *clastics* and the scarp of the Upper Glacials. The triple form to the range is usually due to the presence of the hard conglomerates of the Lower Coal Measures, which rise above the underlying *varves*.

The Werrie Basalt plain is responsible for all the lowland between Quirindi, Currabubula and Piallaway, as well as the Breeza Plains. In the whole of the Werrie basalt area there is not a hill which does not owe its presence either to an intrusion of Warrigundi rock, or an outlier of the Upper Coal Measures.

There is a direct relation, too, between the physiographic curve and the agricultural use to which the land has been put. For example, the mountain country of the Upper Kuttung is invariably barren and carries a very miserable stunted tree-growth, which is rarely cleared. In about forty square miles of Upper Kuttung country in the Werrie Basin region there is not a single cultivation paddock.

The downs of the Lower Kuttung, on the other hand, are always cleared and dotted with homesteads. They provide good pastures and scattered small wheat-paddocks. Access is always easy along the strike, for even though the drainage is usually transverse, with long subsequent tributaries, the lateral divides within the Lower Kuttung are low. A fine example of this rolling grazing country with wheat-farms on the flatter parts, follows the belt of Lower Kuttung rocks between Duri Peak and Kingsmill Peak, and carries on beyond across the open headwater tracts of Coeypolly and Jacob and Joseph Creeks to Wallabadah. A similar Lower Kuttung belt of grazing downs with small areas suitable for cultivation extends through "Royston" and "Merlewood", taking in "Glenoak" and the Oakey Creek paddock of Piallaway Station. Between Duri Peak and Somerton the main pyroxene-andesite cuts out, so the Lower Kuttung belt merges into the wheat-fields of the Burindi Series, and is extensively cultivated.

This narrow Lower Kuttung belt then, from Piallaway via Somerton and Duri Peak to Wallabadah, is an agricultural unit which contrasts strongly with the barren Upper Kuttung ridge-country which overhangs it.

The Burindi and Barraba Series are very suitable, both physiographically and in the soil they have yielded in this climatic environment, for agricultural purposes, and they are extensively cultivated. A continuous wheat-belt follows these rocks from Somerton to the boundaries of the Goonoo Goonoo estate.

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## EXPLANATION OF PLATE XVIII.

Geological Sketch-Map of the Babbinsboon District.

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A NOTE ON THE ASCIGEROUS STAGE OF *CLAVICEPS PASPALI* S. & H. IN AUSTRALIA.

By W. L. WATERHOUSE, The University of Sydney.

[Read 24th November, 1937.]

In 1935 a serious outbreak of ergot in *Paspalum dilatatum* and other species of *Paspalum* occurred in the south-eastern portion of Australia. The sphacelial and sclerotial stages of the causal organism were found throughout this area. The ascigerous stage is known in other countries, but so far has not been recorded for Australia.

Mature sclerotia from *Paspalum dilatatum* were collected in March, 1936, and sown on the surface of soil in pots with a light covering of sand and plant debris. These were subjected to an alternation of freezing and thawing until September. The material in one set was alternately moistened and kept at a temperature of  $-5^{\circ}$  C. for 4 weeks and then dried and maintained at room temperature for 1 week. In another set the material was alternately wetted and frozen at  $-5^{\circ}$  C. for 5 days of each week, and then kept at room temperature for the other 2 days. Following upon this treatment, the pots were kept on the floor of a plant house and the soil kept moist by occasional watering.

Concurrently with this experiment two parallel series of tests were made with *C. purpurea* (Fr.) Tul. on rye. Normal germinations of the sclerotia of both these sets were obtained in September, 1937.

About the middle of October, 1937, the first signs of germination of the sclerotia of *C. Paspali* were noted and they have germinated abundantly since that date.

Investigations are in progress to determine whether any departures from the recorded ascigerous features occur. To date none have been found.

This production of the perfect stage of the fungus has been brought about by artificial treatment of the sclerotia. But there appears to be no reason why natural conditions of weathering should not have the same effect in the field. Ascospore production in Nature may well be important in dissemination and possibly in giving rise to new physiologic races of the fungus.

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- xiii.—Landscapes in the Tamworth district of New South Wales.
- xiv.—Vegetation of Upper Williams River and Barrington Tops districts.
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- xvi-xvii.—Vegetation of the central coastal area of New South Wales.
- xviii.—Geological sketch-map of part of the Babbinsboon district, N.S.W.

## ANNUAL GENERAL MEETING.

WEDNESDAY, 31st MARCH, 1937.

The Sixty-second Annual General Meeting was held in the Society's Rooms, Science House, Gloucester Street, Sydney, on Wednesday, 31st March, 1937.

Mr. C. A. Susasmilch, F.G.S., President, in the Chair.

The minutes of the preceding Annual General Meeting (25th March, 1936) were read and confirmed.

### PRESIDENTIAL ADDRESS.

Following a well-established practice, I will devote the first part of my address to a brief review of the Society's affairs during the past twelve months.

The concluding part of Volume lxi of the Society's PROCEEDINGS was issued in December. The complete volume (360 plus lxxxiii pages, seventeen plates and 196 text-figures) contains twenty-five papers and, in addition, the memorial accounts of Charles Hedley and Tannatt William Edgeworth David.

Exchanges from scientific societies and institutions totalled 2,156 for the session, as compared with 1,703, 1,795 and 1,865 for the three preceding years. During the past year the following institutions have been added to the exchange list: Centre National de Recherches agronomiques, Versailles; Lingnan Science Journal, Canton; Société Royale Entomologique d'Egypte, Cairo; Station biologique de Roscoff, Paris; and Takeuchi Entomological Laboratory, Tokyo.

Since the last Annual Meeting the names of thirteen members have been added to the list, three members have been lost by death, three have resigned, and the names of four have been removed on account of arrears of subscription.

ARTHUR HENRY SHAKESPEARE LUCAS, who died at Albury, N.S.W., on 10th June, 1936, was born at Stratford-on-Avon, England, on 7th May, 1853. The son of Rev. Samuel Lucas, F.G.S., a Methodist minister, with a sound knowledge of geology, he grew up in a scientific atmosphere. He was educated at New Kingswood School, Bath, and at Oxford University, where he was an exhibitioner at Balliol College. He obtained the degrees of Master of Arts of Oxford and Bachelor of Science of London. After holding a mastership at the Leys School, Cambridge, under Dr. W. F. Moulton, he came to Melbourne in 1883, and taught Mathematics and Science to the senior classes at Wesley College and also lectured in Natural Science at the University Colleges, Trinity, Ormond and Queen's. In 1893 he moved to Sydney as Headmaster of Newington College, from which post he retired in 1898 to become Mathematics and Science Master at the Sydney Grammar School, where later he became Headmaster. For a time he lectured in Physiography at the University of Sydney. He retired from school work in 1923, but later, for two years (1924-1926), he accepted appointment as Professor of Mathematics at the University of Tasmania.

While he was in Victoria he was actively interested in the Field Naturalists' Club, being the first editor of the *Victorian Naturalist*, and President of the Club 1887-1889.

He was President of this Society for the two years 1907-09, and was a member of Council from 1895 until his death, with the exception of the two years he spent in Tasmania.

The greatest part of his published work is contained in numerous papers dealing with the Algae, on which he was a recognized authority. He was an indefatigable collector, and after his retirement he spent several months each year in collecting seaweeds from many parts of the Australian coast. He was Honorary Curator of Algae at the Sydney Botanic Gardens for many years. His own large collection of Australian Marine Algae, containing some 5,000 specimens, he bequeathed to the Commonwealth Government.

Apart from his two Presidential Addresses, he contributed sixteen papers (two in conjunction with C. Frost) to our PROCEEDINGS during the years 1894-1936. Most of these papers were the results of his studies on Algae, but several of the earlier ones dealt with Australian Lizards.

The range of his work is indicated by the fact that, apart from his work on Algae, he published an "Introduction to Botany" (in collaboration with Professor Dendy) and "The Animals of Australia" and "The Birds of Australia" (both in collaboration with D. le Souef).

He was Local Honorary Secretary of the Australasian Association for the Advancement of Science for Victoria in 1892, and was President of the Geography Section at the Brisbane (1909) meeting.

In addition to his scientific attainments he was an accomplished linguist, having a sound knowledge of several modern languages (including Spanish, Italian and Russian) as well as Latin and Greek. As a teacher he was lucid, thorough, and inspiring, and his amazing versatility is indicated by the fact, recorded by one of his biographers, that "in the days of the old Senior Examination his boys won medals in thirteen different subjects, and it was his personal teaching that produced so remarkable a result". Notwithstanding his wide range of accomplishments, he was a remarkably modest man, and thus he deserved far more public recognition than he ever got. Those who knew him, however, were able to appreciate his lovable disposition, his kindness and sympathy, and his charming modesty.

ROBIN JOHN TULLYARD was born on 31st January, 1881, at Norwich, England, and died in Goulburn District Hospital on 13th January, 1937, as a result of a motor accident while driving from Canberra to Sydney. His early education was at Dover College, from which he won scholarships to Oxford for classics and to Cambridge for mathematics. He chose the latter and proceeded to Queens' College, Cambridge. He obtained his degree of Bachelor of Arts in mathematics in 1903, and in the following year read Oriental languages and theology, but rheumatism compelled him to leave England, and he accepted appointment as a master in science and mathematics at Sydney Grammar School. He graduated Master of Arts of Cambridge in 1907. In 1913 he was admitted as a Research Student in the University of Sydney and awarded a Government Science Research Scholarship, which he held for two years, graduating Bachelor of Science in 1914. He obtained his Doctorate in Science at Sydney in 1918. He held a Linnean Macleay Fellowship in Zoology from 1915 to 1920, in which year he was appointed Chief of the Biological Department of the newly-established Cawthron Institute at Nelson, N.Z. During his tenure of the Macleay Fellowship he was granted leave of absence for a period in 1917 to act as Lecturer in Zoology at the University of Sydney. In 1926 he became Assistant-Director of the Cawthron Institute, and in 1928 returned to Australia as Chief of the Division of Economic Entomology of the Council for

Scientific and Industrial Research, from which he retired on account of ill-health in 1934.

He had a brilliant career as an Entomologist, the results of his researches appearing in his two books "The Biology of Dragonflies" (1917) and "The Insects of Australia and New Zealand" (1926) and some two hundred papers in the journals of scientific societies. His early work was mostly on the Odonata, while during his term as a Linnean Macleay Fellow he worked on a wide variety of entomological problems, including wing venation and other characters of the Odonata, Australian Neuroptera, Australian Mecoptera, the Panorpid Complex, and fossil insects of Permian and Triassic age in Queensland and New South Wales. In New Zealand, and subsequently at Canberra, he necessarily devoted a large portion of his time to the measures necessary to combat a number of insect pests, but, with his amazing energy, he continued his own work on various insect groups, particularly those found abundantly as fossils. For several years he collaborated with the late Sir Edgeworth David in investigating fossil remains, from rocks of Pre-Cambrian age in South Australia, which they believed to be the remains of primitive crustaceans. Some of their results have been published as a Memoir on Fossils of the late Pre-Cambrian from the Adelaide Series.

His scientific publications brought to him many honours: he was elected Fellow of the Royal Society, London (1925), Fellow of the New Zealand Institute (1924), Corresponding Member of the Zoological Society, London (1921). Cambridge University conferred on him its Doctorate in Science (1921), and Queens' College elected him an honorary Fellow. He was awarded the Crisp Medal (1917) by the Linnean Society of London, the Trueman-Wood Medal (1926) by the Royal Society of Arts and Science, London; the R. M. Johnston Memorial Medal (1929) by the Royal Society of Tasmania; the Clarke Memorial Medal (1931) by the Royal Society of New South Wales; and the Mueller Medal (1935) by the Australian and New Zealand Association for the Advancement of Science. He was president of the Zoology Section of the New Zealand Science Congress at Dunedin in 1924, and of the Zoology Section of the Australian and New Zealand Association for the Advancement of Science at Brisbane in 1930. He had been a member of this Society since 1904, and contributed eighty-nine papers to the PROCEEDINGS during the years 1905-1935.

WALTER WILSON FROGGATT, who died at Croydon on 18th March, 1937, was born at Melbourne, 13th June, 1858. The son of George W. Froggatt, a mining engineer, he was educated at the Corporate High School, Bendigo, Victoria. Both his parents were keen nature lovers, and so he early developed his love of natural history. On account of ill-health he spent some years on the land in north-west Victoria, and droving in western New South Wales and Queensland. In Queensland he also spent some time on various goldfields—Mt. Brown, Cairns, Herberton and Flinders. During this time in the country he developed his interest in the study of insects, which he collected widely. Through this he met Baron F. von Mueller, then Government Botanist of Victoria, and, partly as a result of the Baron's good offices, he was appointed entomologist and assistant zoologist to the scientific exploring expedition to New Guinea despatched by the Royal Geographical Society of New South Wales. After his return he was engaged by Sir William Macleay, as collector for his private museum, from 1886 to 1888. During this period he collected in northern Queensland, and also in north-western Australia, in the back country of the Kimberleys. From 1889 to 1896 he was assistant and collector at the Sydney Technological Museum under the late J. H. Maiden, and in 1896 he was appointed Government Entomologist, which position he occupied

until he retired in 1923. After his retirement he was special Forest Entomologist to the Forestry Commission of New South Wales from 1923 to 1927. For ten years after the institution of the Faculty of Agriculture, he lectured in *Entomology* at the University of Sydney.

He had been a member of this Society since 1886, was President 1911-1913, and a member of Council from 1898 till his death. He contributed to the *PROCEEDINGS* some forty-nine papers (one in conjunction with F. W. Goding) in addition to his two Presidential Addresses.

He took the greatest interest in all naturalist societies, and was always an active member of the Naturalists' Society of New South Wales, of which he was President for some years; he was a member of the Council of the Royal Zoological Society of New South Wales, which elected him a Fellow in 1931. He was also a member and one of the founders of the Wattle League, Wild Life Preservation Society, and the Gould League of Bird Lovers. He was a member of the Australian National Research Council, 1921-1932, and a Fellow of the Linnean Society of London.

His scientific writings covered a wide range in entomology, and comprised many departmental reports in addition to his contributions to the publications of scientific societies. He was also the author of "Australian Insects" (1907), "Some Useful Australian Birds" (1921), "Forest Insects of Australia" (1923), and "Forest Insects and Timber Borers" (1927), as well as handbooks on Insects (1933) and Spiders (1935). In the course of his work he was sent on a world tour to study insect pests in general and fruit pests in particular for the Governments of South Australia, Victoria, New South Wales and Queensland; in 1909 he visited the Solomon Islands at the invitation of Levers' Pacific Plantations, and in 1913 went to the New Hebrides at the request of the French Planters' Association.

During the past year the David Memorial Fund was closed, the result being that a sum of £2,079 was handed to the Senate of the University of Sydney, which has decided that the interest shall be used for the establishment of a post-graduate travelling scholarship for Geology to be known as the Edgeworth David Scholarship. The Senate of the University also decided that in future the Chair of Geology shall be called the "Edgeworth David Chair of Geology".

The Council of the Society also gave its support to a proposal to obtain a portrait of the late Sir Edgeworth David, to be hung in Science House. The Committee appointed for the purpose of carrying out this project received sufficient subscriptions from members of the societies associated in Science House, and has commissioned Mr. Norman Carter to paint the portrait.

In an effort to expedite the appointment by the Government of Trustees for the Sir Joseph Banks Memorial Fund, the Council arranged for a deputation to wait on the Acting-Premier in May last year. The deputation was received by Major Shand (in the absence of the Acting-Premier), and received a sympathetic hearing, but I regret to say that the Government has not yet brought forward the necessary formal legislation to enable the trust to be appointed.

The proclamation by which numerous wild flowers are afforded protection was renewed for a further period of a year from 1st July, 1936.

With the object of ensuring that type material of species from Australia and the Mandated Territories should be available for scientific workers in Australia, your Council asked the Commonwealth Government to extend the principle approved by it in 1923 for Australia, that the types of new species and duplicates of rare species collected by expeditions should be deposited in an Australian

Museum, to the Mandated Territories. The Society was notified in September, 1936, that "in future special permits to collect in New Guinea will contain a condition that types of new species and duplicates of any rare species obtained must be donated to the Administration of the Territory", and in December, 1936, "That the Lieutenant-Governor of Papua proposes to declare all specimens of flora and fauna to be prohibited exports except with the consent of the Treasurer, such consent to be given after the collector has furnished an undertaking that he has not collected any new or rare specimens or that he is sending or has sent certain specimens to Canberra."

The vacancy in the Council resulting from the death of Mr. A. H. S. Lucas was filled by the election of Mr. R. H. Anderson, B.Sc.Agr.

The year's work of the Society's research staff may be summarized thus:

Mr. H. L. Jensen, Macleay Bacteriologist to the Society, continued investigations into nitrogen-fixation in wheat soils. In twenty-six soils to which no extra source of energy was added, completely negative results were obtained. In soils to which glucose or straw had been added, to test the potential N-fixing capacity, only two out of sixteen soils gave a moderate N-fixation under aerobic conditions with the addition of glucose; the addition of straw did not in any experiment result in a measurable gain of nitrogen. Experiments with twelve wheat soils exposed to daylight to test the possible importance of algae gave negative results, but one other soil showed a significant gain of nitrogen. No aerobic organism other than *Azotobacter chroococcum* (the only species of *Azotobacter* so far encountered) has yet been found capable of fixing elementary nitrogen. Pure cultures of this species were found capable of assimilating 12-15 mgm. of elementary nitrogen per gram of glucose consumed. Since the assimilation of 10 mgm. N per gram of glucose is considered a normal amount, the lack of N-fixation in the wheat soils cannot be ascribed to inefficiency of the *Azotobacter* strains. Unfavourable soil reaction (acid) seems in most cases responsible for the absence of N-fixation. Nitrification experiments with thirty soils have shown a close correlation between total N-content and nitrate production. The conclusion is indicated that it cannot be assumed that the processes of non-symbiotic nitrogen fixation will suffice to compensate the wheat lands for the gradual removal of nitrogen by continued cultivation of wheat, particularly if stubble-burning is regularly practised.

Miss Lillian Fraser, Linnean Macleay Fellow of the Society in Botany, continued her work on the Sooty Moulds of New South Wales, completing two papers for publication and preparing a thesis containing results of all her work on this subject. In this thesis she attempts to show (a) that there is a distribution and typical assemblage of sooty-mould fungi which is dependent directly on the ability of the individual species to resist heat and desiccation, and (b) to explain the reason for the predominance of members of the Capnodiaceae and certain other species in sooty-mould colonies, their absence from other habitats occupied by decay-causing fungi, and the absence or relative unimportance of decay-causing fungi in sooty-mould colonies. One paper, "Notes on the Occurrence of the Trichopeltaceae and Atichiaceae in New South Wales" appeared in the PROCEEDINGS for 1936, and another, "The Distribution of Sooty-mould Fungi and its Relation to certain Aspects of their Physiology", is complete and will appear in the PROCEEDINGS for 1937. With the object of finding reasons for the composition of sooty-mould colonies and the absence of common saprophytes, a series of experiments was carried out to ascertain the effect in culture of the growth of individual species upon the growth of other species. It was found that, whereas true sooty-

mould fungi do not retard each other's growth to any great extent in culture, the same species do retard the growth of *Penicillium*. This may in part explain the ability of a large number of sooty-mould species to grow together in the one colony, and also the absence of the common saprophytes. Studies of the behaviour of gas bubbles in living sooty-mould cells have shown that the bubbles are within the protoplast and controlled by its properties. The composition of the gas under various conditions of desiccation has been determined, but further work is necessary on this. It has been shown that gas must be able to diffuse slowly across the dry cell-wall, that a certain amount of gas can accumulate in a cell which has never had access to air, and that the cell-wall can absorb moisture from a nearly saturated atmosphere in sufficient quantity to allow for growth of the hyphae. This latter property is no doubt responsible for the ability of sooty-mould fungi to colonize the habitats in which they are found. An ecological survey of the rain forests and Eucalypt forests of the Upper Williams River and Barrington Tops Plateau which was undertaken in collaboration with Joyce Vickery, M.Sc., of the National Herbarium, Botanic Gardens, is being completed.

Dr. I. V. Newman, Linnean Macleay Fellow of the Society in Botany, continued genetical work by an examination of anthesis of *Acacia discolor* and by carrying out experiments with pollination to find the time of ripening of the stigma and the periods between pollination, germination of pollen, and fertilization. This work was incomplete at the time of his resignation from the Fellowship. A germination test was made with seeds of *Acacia Baileya* collected from two localities near Cootamundra. The test gives no indication of segregation of widely divergent foliar characters, the variations shown being such as might be expected from open pollination in a wild species (without crossing). The recording of this test was not completed at the time of resignation. The investigation of polyspermy was retarded by considerable technical difficulties in handling and sectioning, at the great thinness necessary, the carpels which are such small, hard objects. Dr. Newman hopes to complete these investigations as opportunity offers.

Mr. R. N. Robertson, Linnean Macleay Fellow in Botany, continued his investigations of the gas of the intercellular spaces of leaves and made progress on the problem of daylight movement of stomata and the changes of gas composition with change in external factors. Mr. Robertson was awarded a Science Scholarship by the Royal Commissioners for the Exhibition of 1851, and resigned his Fellowship as from 31st July, 1936. He proceeded to Cambridge, where he will continue this work on plant physiology, in which we wish him every success.

Miss Elizabeth Pope, Linnean Macleay Fellow of the Society in Zoology, has carried out dissections of the Port Jackson Shark, and has completed studies of the external features and the exoskeleton. She has also made a study of the anatomy of the digestive system and discovered the presence of  $9\frac{1}{2}$  spiral folds in the large intestine, and not  $8\frac{1}{2}$  turns as stated by T. J. Parker. The muscle system and the nervous system have been studied and dissections of the blood vessels and skeleton are in progress. Miss Pope has carried out a preliminary survey of the Ecology of a certain area at Long Reef. Some definite idea of the animal communities has already been obtained and now it should be possible to work out some of their inter-relations. During the coming year Miss Pope proposes to continue the investigations on the Port Jackson Shark, and the ecological problems in connection with the work at Long Reef.

Six applications for Linnean Macleay Fellowships were received in response to the Council's invitation of 30th September, 1936. I have pleasure in reminding

you that the Council reappointed Dr. I. V. Newman and Miss Elizabeth C. Pope to Fellowships in Botany and Zoology respectively for one year from 1st March, 1937, and appointed Mr. Consett Davis, B.Sc., and Mr. A. H. Voisey, M.Sc., to Fellowships in Zoology and Geology respectively for one year from 1st March, 1937. Shortly after the announcement of these appointments, Dr. I. V. Newman was appointed Lecturer in Botany at Victoria University College, Wellington, N.Z., and resigned his Fellowship as from 30th November, 1936. The Council, thereupon, decided to invite applications from qualified candidates to fill the vacancy caused by Dr. Newman's resignation. Three applications were received, and I have pleasure in announcing the appointment of Miss Ilma M. Pidgeon, B.Sc., to a Fellowship in Botany for the year 1937-38. We may wish all four Fellows a successful year's work.

Mr. Consett Davis, after a distinguished course, graduated in Science with First Class Honours in Entomology (1934) and Botany (1935). During his Honours course he carried out research on the Australian Embioptera and on the Plant Ecology of the Bulli District, part of the results of which have already appeared in three papers in the PROCEEDINGS for 1936. For his work as a Linnean Macleay Fellow he proposes to continue the work already commenced on the Embioptera, and also to work on the respiration of the Dryopidae, the wing venation of the Coleoptera and the anatomy of certain littoral Mollusca. As opportunity arises he proposes also to study the general ecology of the Five Islands.

Mr. A. H. Voisey gained First Class Honours and the University Medal in Economic Geology on graduation in Science in 1933 and also divided the John Coutts Scholarship. During his University course and subsequently, Mr. Voisey carried out a considerable amount of field investigation of the Upper Palaeozoic rocks of north-eastern New South Wales, and he has thrown much light on problems of the Carboniferous and Permian Systems which were hitherto obscure. Several papers embodying results of this work have already been published by our Society and by the Royal Societies of New South Wales and Queensland, resulting in Mr. Voisey obtaining the degree of M.Sc., from the University of Sydney in 1936. Mr. Voisey proposes to continue this work with the object of elucidating the structures in the Permian System and ultimately obtaining stratigraphical sequences which will permit of satisfactory correlation with the successions in other parts of Eastern Australia and perhaps with extra-Australian successions.

Miss Ilma M. Pidgeon graduated in Science in the University of Sydney in 1936 with First Class Honours in Botany and was awarded a Government Science Research Scholarship in 1936. During her final year and subsequently she carried out work on the Ecology of the Hawkesbury Sandstone and Wianamatta Shale Formations of the Sydney District, and has completed one paper entitled "Plant Succession on the Hawkesbury Sandstone, Sydney District", which has been submitted for publication. A second paper on "The *Eucalyptus* Forests of the Hawkesbury Sandstone" is approaching completion. She has also been working on the *Eucalyptus* Forest Associations on the Wianamatta Shales, and the nature and distribution of the brush forests. As a Fellow she proposed to extend the work on the *Eucalyptus* Forest Associations of sandstone and shale and to complete other aspects of the ecological work arising out of these studies.



## THE GEOLOGICAL HISTORY OF THE CAINOZOIC ERA IN NEW SOUTH WALES.

*Introduction.*

For the scientific part of my address this evening I have chosen as my subject a review of the geological history of the Cainozoic Era in New South Wales. A study of the published work on this subject shows that widely divergent views have been expressed by the various writers, and it seems desirable, therefore, to review the existing knowledge for the purpose of attempting to provide a more satisfactory account of our Cainozoic history.

The absence of fossiliferous marine strata of Cainozoic age in New South Wales, except for a small area in the south-west corner of the State, together with the unsatisfactory evidence of geological age afforded by our Cainozoic fossil plants, makes the accurate dating of such Cainozoic formations as do occur practically impossible. In Victoria, however, marine fossiliferous strata of Cainozoic age are widespread, and the association of these with other Cainozoic formations, such as the volcanic rocks and their associated deep-leads, gives more definite evidence of age than can be found in New South Wales; the writer has found it necessary, therefore, to make an attempt to correlate the Cainozoic formations of the two States in the hope that such a correlation would provide evidence lacking in New South Wales. With this object in view the published literature has been studied, certain areas in Victoria have been personally visited and, in addition, a number of features have been discussed with some Victorian colleagues who have cordially assisted in every way; in this connection I am particularly indebted to Messrs. W. Baragwanath, F. A. Singleton and R. A. Keble.

*Previous Observers.*

C. S. Wilkinson (1882) and E. F. Pittman (1908) published very brief summaries of the Cainozoic Era in New South Wales, but the first real attempt to interpret the history of this era was that made by E. C. Andrews. He was the first geologist in Australia to study the origin of the existing land forms and use that study in the interpretation of its Tertiary and Post-Tertiary history; in making these physiographical studies he also, of course, made use of such direct geological evidence as was available. The result of his work was published in 1910 under the title of the Geographical Unity of Eastern Australia in late Tertiary and Post-Tertiary Time (Andrews, 1910). His methods and conclusions met with much criticism at the time and even to-day there are some Australian geologists who disagree with some of his most important conclusions, but in the writer's opinion his interpretation of our Cainozoic history has proved to be thoroughly sound and, apart from some very minor modifications, the succession of events postulated by him and the geological ages assigned to them have proved to be correct. In 1911 the present writer in his book on the Geology of New South Wales (Sussmilch, 1911) gave a fairly detailed description of the Tertiary formation of New South Wales, the chronological succession adopted being based on Andrews' published work of the previous year; and in 1925 (Sussmilch, 1925) published a brief description of the topographical features of New South Wales, which included a table showing the more important events of the Cainozoic Era arranged in chronological order.

T. W. E. David (1914), in a summary of the geology of Australia, included a brief chapter on the Tertiary Period, and in his Explanatory Notes to accompany a new Geological Map of Australia (David, 1932) included a fairly detailed

summary of the Cainozoic Era; in this account his dating of some of the formations differs somewhat widely from that of previous writers.

R. Henry Walcott (1920) contributed a very useful paper dealing with the evidence of age of some Australian gold-drifts, in which he reviews the whole of the existing literature relating to this subject for both Victoria and New South Wales; he gives full lists of the fossil plants and a very useful list of references.

F. Chapman and F. A. Singleton (1925) published a very useful summary of the Tertiary Deposits of Australia, which deals with both the marine and non-marine formations and includes a very complete bibliography.

A study of the above and other publications on this subject shows that wide differences of opinion exist, not only as to the order of succession of events which took place during the Cainozoic Era, but also as to their actual geological age.

The interpretation of our Cainozoic history depends upon the following evidences: (1). The Fluvatile Deposits; (2). The Volcanic Rocks; (3). The Marine Formations; (4). The Existing Land-forms.

#### *The Fluvatile Deposits of New South Wales.*

At many places in New South Wales old river-channels of Tertiary age are found partly filled with deposits of alluvium consisting of river gravels covered by layers of sand and clay and, in some cases, beds of lignite. The bottom gravels of many of these old river-channels contain alluvial gold, tinstone, gem-stones, etc., and are known to the alluvial miner as "deep-leads". These fluvatile deposits are usually well stratified and at most localities contain fossil fruits or fossil leaves or, in some cases, both. At nearly all localities the alluvial deposits are covered by contemporaneous flows of basalt and, in some instances, basalt flows are actually interstratified with the fluvatile deposits. Similar deposits also occur in Queensland and in Victoria. A brief description of the best known of these deposits is desirable and all of those selected for this purpose in this State have been visited by the writer.

(a) *The Emmaville (Vegetable Creek) Leads.*—These occur on the New England Tableland in northern New South Wales, not very far from the Queensland border; they were first described in detail by T. W. E. David (1887), and further descriptions were given by J. E. Carne (1911); as they have been described in full detail they may be taken as a type of our Tertiary fluvatile deposits and described more fully than those which follow. The Tableland at Emmaville has an altitude of about 2,900 feet and consists dominantly of granites and quartz-porphyrries, with which are associated subordinate areas of highly folded Upper Palaeozoic strata; the surface of the tableland is a peneplain cut out of these rocks. Rising above the general level of the tableland is a monadnock called Mt. Battery, 3,970 feet in altitude, a residual of the older tableland, out of which the peneplain was developed.

The fluvatile deposits and their associated lava flows lie in shallow valleys about 300 feet deep incised in the surface of the tableland; a section of these deposits showing their mode of occurrence is given in Figure 1. Two basalt-covered leads, the Vegetable Creek Lead and the Graveyard Lead, are shown in this section. At the right of the section is shown the valley of the Severn River, cut out during the present cycle of erosion subsequent to the uplift of the tableland; it will be seen that the development of this present-day valley has partly cut away one of the valley walls of the old lead channel.

In describing these leads, David has shown that the fluvial deposits underlying the basalts range from 25 feet to 79 feet in thickness, while the basalts range up to 200 feet in thickness; he has also shown that there are two separate flows of basalt, with evidence of an erosion interval between them; he states that: "In Skinner's Rock shaft there is conclusive proof of at least two flows of basalt belonging to different periods. This shaft was sunk through 100 feet of soft basalt on to beds of fine sand and clay 25 feet thick and the latter was found to rest upon the waterworn surface of hard basalt." David considered that the erosion interval between the two basalt-flows represented a long period of time, and he placed the main auriferous lead with its basalt cover in the Eocene Period, while the overlying 25 feet of alluvium with its covering flow of basalt was considered to be as young as Miocene or even Pliocene. In his latest writing on this subject (David, 1932) he places the older deposits in the Oligocene and the newer in (?) the Miocene Period.

A study of David's sections will show that, even allowing for the erosion interval between the two basalt-flows, there is no valid reason why the whole series could not have been deposited not only in one geological period but even in part of a period. J. E. Carne was evidently of this opinion because, in the geological map which accompanied his report on the Emmaville tinfield in 1911, all of these deposits are included in the Eocene Period.

A large number of fossil leaves have been obtained from these fluvial deposits and these have been described by Baron von Ettingshausen (1888); he described 80 different species from the Old Rose Valley lead and 35 species from Witherden's Tunnel; both of these localities are from the same horizon, i.e., under the lower basalt-flow, yet only one of the 95 species described is common to the two localities. Sixteen species were described from Fox and Partridge's claim, obtained from a shallow lead above the lower basalt-flow, none of which is listed from the localities previously mentioned. However, from collections of fossil leaves obtained from one and the same lead at Newstead, near Elsmore, about 20 miles from Emmaville, 30 species have been described by Ettingshausen and others. Twenty-one of these species occur in Ettingshausen's lists from Emmaville, eight from the Old Rose Valley lead, nine from Witherden's Tunnel, and four from Fox and Partridge's. There seems no doubt, therefore, that the fossil plants obtained from Emmaville all belong to one and the same fossil flora. Ettingshausen was of opinion that this flora deviates strikingly from the present-day flora and assigned a Lower Eocene age to it; these opinions will be discussed in a later section.

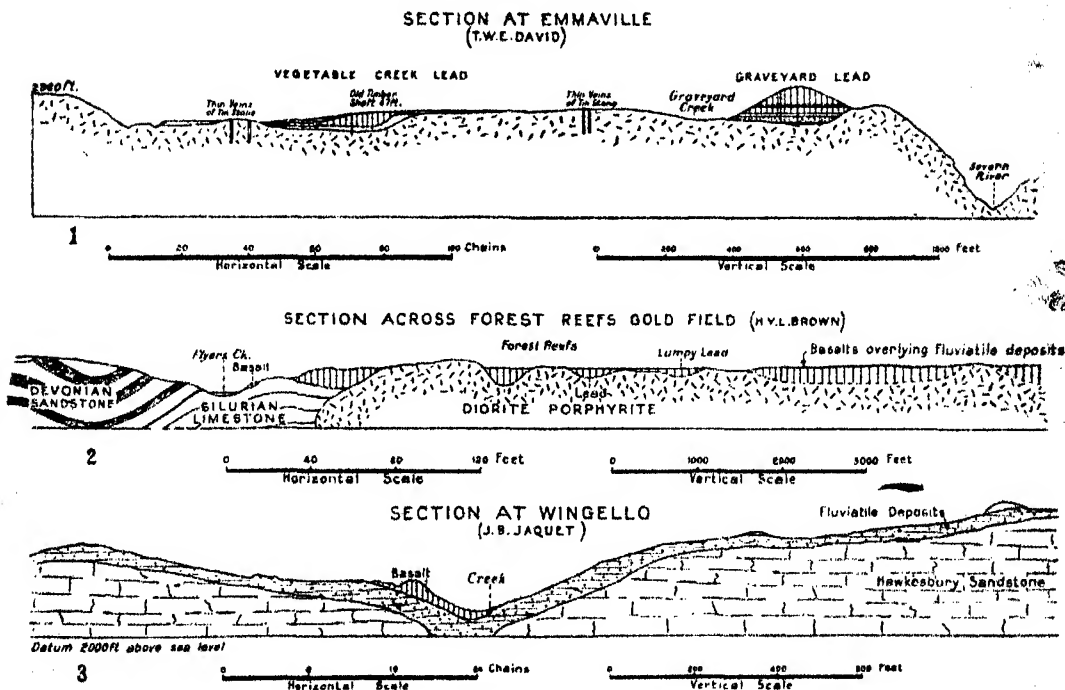
The history revealed by the Emmaville leads and their associated land-forms indicates the following stages of development:

1. Development of a peneplain at sea-level;
2. Elevation of this peneplain by about 300 feet;
3. Development of valleys to a depth of 300 feet;
4. The partial filling of these valleys with the fluvial deposits and lava flows;
5. Continuation of valley development with the production of a system of shallow mature valleys alike in the basalts and older rocks;
6. An uplift of about 2,900 feet to produce the existing tablelands;
7. Cutting out of the valleys of the present cycle of erosion.

(b) *The Gulgong Leads.*—These occur near the village of Gulgong, on a tableland with an altitude of about 1,600 feet; the surface of this tableland is a

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penepain cut out of a series of highly-folded Palaeozoic strata and their associated plutonic intrusions. The leads occur in shallow valleys incised in the surface of this penepain and are, for the most part, covered by basalt-flows; the fluviatile deposits range from a few feet up to 200 feet in thickness, while the basalts range up to 180 feet thick. Fossil fruits were obtained from the Home Rule Lead at a depth of 126 feet; these were described by von Mueller (1876) and referred to the Pliocene Period. C. S. Wilkinson (1878) reported that some bones of fossil vertebrates had been obtained from the Magpie Lead at a depth of about 40 feet, and included remains of *Diprotodon*, *Halmaturus* and *Macropus*.



(c) *The Forest Reefs Leads.*—These occur on the Central Tableland of New South Wales not many miles from the town of Orange, and have been described by H. Y. L. Brown (1882); a section showing their occurrence is given in Figure 2; it will be seen from this that the surface of the tableland here is a penepain cut out of highly-folded Lower Palaeozoic strata intruded by basic granites and porphyrites; incised in its surface are a number of Tertiary stream channels now partly filled with fluviatile deposits covered by basalt lava flows, the latter ranging up to 200 feet in thickness. The alluvial deposits have yielded fossil fruits similar to those obtained at Gulgong.

(d) *The Warrumbungle Mt. Leaf-Beds.*—At the Warrumbungle Mountains, near Coonabarabran, thin beds of sand and clay have been found interstratified with trachyte lava flows. The extinct volcanoes, of which these lava flows form a part, stand upon a tableland about 2,000 feet in altitude. Fossil leaves have been

obtained from the shale beds and described by Henry Deane (1907), who states that "the leaves are somewhat similar in character to many of those described by Ettingshausen from the deposits from Dalton and Vegetable Creek".

(e) *The Wingello Leaf-Beds*.—These occur near the village of Wingello, on the Mittagong-Marulan Tableland at an altitude of 2,200–2,300 feet, the surface of which at this locality consists of Triassic sandstones (Hawkesbury Sandstones), and have been described by J. B. Jaquet (1901). The fluvial deposits consist of ferruginous shales, sandy claystones and coarse-grained sands, deposited in shallow valleys, about 300 feet deep, cut into the Hawkesbury Sandstones, as shown in Figure 3. They are covered in part by basalt-flows and have yielded fossil leaves which have been described by Henry Deane and obviously belong to the same fossil flora as that obtained from Dalton and Emmaville.

(f) *The Leaf-Beds at Dalton*.—These occur at the village of Dalton, about 7 miles from the township of Gunning. The country here consists of a tableland with a general altitude of about 1,900 feet. The surface of the tableland is a peneplain cut out of a series of highly-folded Silurian strata intruded by granite. Traversing the surface of the tableland is a series of mature valleys about 300 to 400 feet deep and with aggraded floors. Typical examples of these mature valleys are given in Plate A. At Dalton deposits of cemented siliceous gravels and sands occur some 50 feet above the floor of the valley and these contain abundant fossil leaves. These have been described by Ettingshausen (1888) (27 species) and referred by him to the Eocene Period.

(g) *The Kiandra Leads*.—These occur near the village of Kiandra on the Southern Tableland and have been described in detail by E. C. Andrews (1901). The tableland here has an altitude of over 5,000 feet and its surface is a peneplain cut out of highly-folded Lower Palaeozoic sediments (tuffs and slates) with granite and syenite intrusions; above the tableland surface rise monadnocks, such as Governor's Hill (5,723 feet), residuals of the older tableland out of which the peneplain has been eroded. The leads lie in shallow valleys cut into the peneplain surface and consist of river gravels covered by layers of sand, clay and lignite ranging up to 150 feet in thickness, the whole covered by a flow of basalt. The main lead has been traced for a distance of about 20 miles and lies in a rock channel about 10 chains in width. Present-day streams have cut their channels on either side and well below the base of the lead, so that it now occurs on top of a ridge; the upper surface of the basalt is, however, somewhat below the general level of the tableland. No fossil leaves or fruits have been described from this lead. Since its uplift, the Kiandra tableland has been deeply dissected; at the fifteen-mile the Tumut River is entrenched in a gorge 2,500 feet deep, and where this stream joins the Yarrangobilly River the gorge is 3,600 feet deep.

From the descriptions given it will be seen that all of these fluvial deposits, with their associated basalts, are similar in their geological characters and in their physiographical setting; they differ only in the altitude of the tableland upon which they rest; they would therefore appear to be all of the same geological age.

#### *The Fluvial Deposits of Victoria.*

It is proposed in this section to describe briefly some of the Tertiary fluvial deposits of Victoria for the purpose of showing their close relationship to those of New South Wales as well as their relationships to one another.

I. *Eastern Victoria.*

(a) *The Leads of the Bogong and Dargo High Plains (Victoria).*—These occur in Eastern Victoria not many miles from the New South Wales border, and have been described by Stanley Hunter (1909). Their physiographic setting is identical with that of the various leads described from New South Wales; the tableland on which they occur has a general altitude of about 6,000 feet, but appears to have a definite southerly tilt. The surface of this tableland is a peneplain cut out of Lower Palaeozoic strata, and lying in shallow valleys cut into this peneplain surface are fluviatile deposits covered by sheets of basalt. The higher points of the tableland, such as Mt. Feathertop (6,303 feet), Mt. Fainter (6,160 feet), Mt. Hotham (6,101 feet) and Mt. Cope (6,015 feet) all occur in the older rocks.

The basalts to-day cover a series of disconnected areas on or near the main divide, and these areas are so level as compared with the rugged topography which surrounds them that the more extensive areas are known as plains such as the Bogong High Plains, the Baw Baw Plains and the Dargo High Plains. The basalts reach an altitude of 5,935 feet at the northern end of the area (Bogong High Plains), the altitude decreasing to 4,400 feet at the south end of the Dargo High

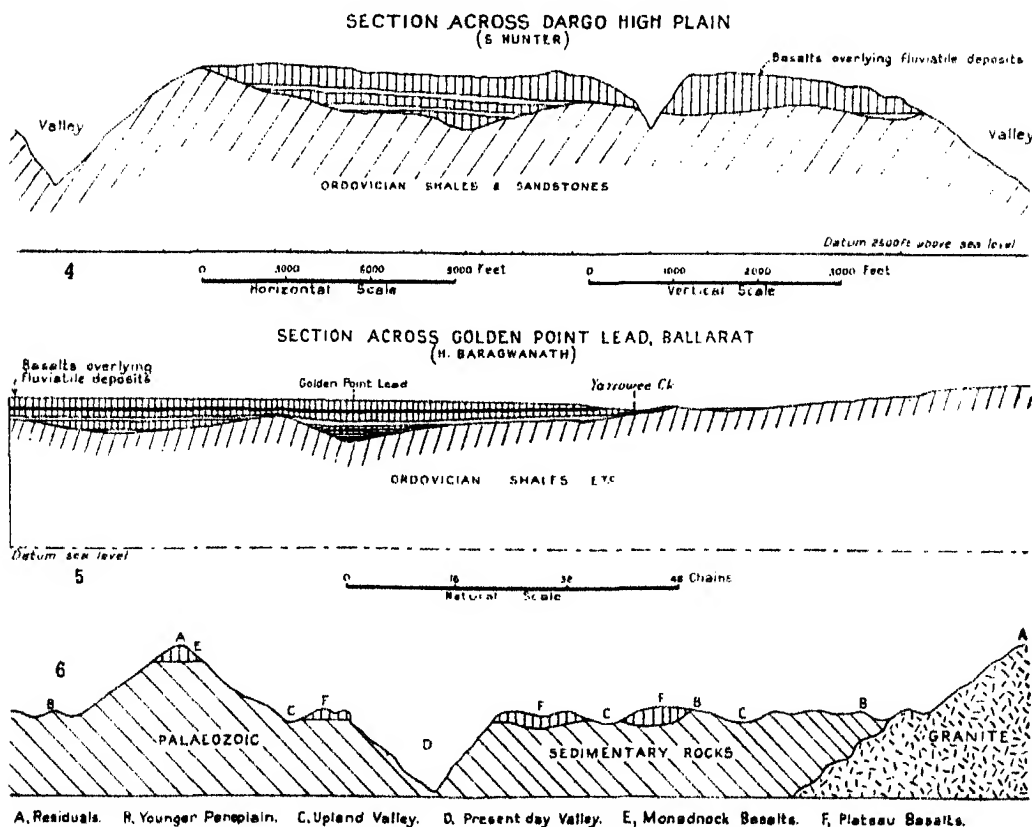


Fig. 6.—Ideal section across tableland, showing main physiographical features.

Plains, a decrease in altitude of 1,500 feet in a distance of about 22 miles, suggesting that the tableland was tilted during its uplift.

A study of Stanley B. Hunter's sections (1909) on the State Geological Map of the Dargo High Plains (see Fig. 4) shows that the fluviatile deposits with their basalt cover are similar in all respects to those occurring in New South Wales, while the tableland on which they occur has suffered a similar deep dissection to that of the Kiandra Tableland of New South Wales.

Fossil leaves have been obtained from these deposits and were described by F. McCoy (1876) who considered them to be of Lower Miocene age, and it is upon this evidence apparently that these deposits have since been referred by most Victorian geologists to the Miocene Period and the basalts referred to the Older Basalt Series of Victoria.

(b) *Aberfeldy*.—The geology and physiography of this area have been fully described by H. Baragwanath (1925); according to his description there is in this district a much dissected tableland ranging from 3,260 to 3,500 feet in altitude, but with a definite tilt towards the south; the one-time surface of the tableland is a peneplain cut out of Ordovician strata. Rising above the level of this peneplain are two residuals, Mt. Baw Baw (5,130 ft.) and Mt. Useful (4,765 ft.); these are remnants of the older tableland out of which the peneplain was eroded. The two main rivers of the district are the Aberfeldy and Thompson Rivers, and the divide between these two streams is capped at intervals along a distance of about 20 miles by patches of basalt, under which in places occur river gravels. No fossil plants have been described for these deposits. The physiographic setting here is very similar to that of the Dargo High Plains.

(c) *The Tangil Lead*.—This has been described by R. A. Murray (1880) and occurs on the divide between the Tangil and Latrobe Rivers. The fluviatile deposits here are about 40 feet thick and are capped with basalt, and from the lead fossil fruits (Murray, 1887) have been obtained. These basalts were originally classed as Newer Basalts by R. Brough Smyth (1874) because some of the fossil fruits found were identical with those found in the Haddon Lead in the Ballarat District, but later S. Hunter (1909) referred them to the Older Basalts (Miocene) because he considered the physiographic setting of the Tangil lead to be similar to that of the Dargo High Plains.

(d) *Tangil East and Narracan*.—The geology of this region has been described in detail by H. Herman (1922), and from his description the following important features stand out:

1. The presence of a well-developed peneplain cut out of Silurian and Jurassic strata;
2. The deposition on this peneplain of the following Tertiary formations: firstly, fluviatile deposits consisting of quartz gravels, micaceous sands and beds of lignite, followed, secondly, by basaltic lava-flows ranging from 300 to 500 feet in thickness and, thirdly, deposited upon these basalts are fluviatile deposits (perhaps lacustrine in part) consisting of sands, clays and ferruginous conglomerates with a maximum thickness of 100 feet.

Herman, following the general practice, referred the basalts to the Older Basalt Series of Miocene age and the underlying fluviatile deposits were considered to be of Miocene, Oligocene or Eocene age. At Narracan, in the southern part of the area, these fluviatile deposits have yielded fossil leaves which have been described by F. Chapman (1926), and his list of genera is included in Table I; this fossil flora was considered by him to be the same as that obtained from the

Dargo, Berwick, Bacchus Marsh and Pitfield localities. The fluviatile beds overlying the basalts were doubtfully referred by Herman to the Pliocene period; they have yielded no fossils. In speaking of these latter beds Herman states: "These deposits are evidently of fluviatile and in part at least of lacustrine origin. They were laid upon the flattened surface following the filling of the (?) Miocene river valleys by the volcanic accumulations." Herman's sections show very clearly that the peneplain, with its covering of Tertiary deposits, was subsequently uplifted to form the existing tableland ranging up to 1,200 feet in altitude and that the uplift was a differential one accompanied by faulting and the tilting of the faulted blocks.

(c) *Morwell*.--From the adjoining district of Morwell Herman (1922) has recorded the existence of a freshwater series consisting of sands, clays and lignites with a thickness of upwards of 1,000 feet; of this thickness 780 feet consist of lignites. No marine strata are associated with these beds. At Yallourn the topmost beds have yielded fossil leaves which have been described by H. Deane.

This freshwater series has been termed the Yallournian by F. A. Singleton (1935), and he states that "though these coals have been referred to the Miocene they appear to pass easterly, as shown by borings, beneath the Barwonian marine sediments of East Gippsland whose lowest portion is not younger than the L. Miocene and may even be Upper Oligocene"; he states further that "the aspect of the flora which includes at Morwell (Yallourn) *Banksia*, *Dryandra*, *Lomatia*, *Cinnamomum*, *Phyllocladus* and *Ginkgo* suggests it is not older than Oligocene".

It has been well established by borings that lignites do occur under the Lower Miocene marine strata of East Gippsland (Chapman and Crespin, 1932) at depths of upwards of 1,000 feet, but these lignite beds are of no great thickness. More recent borings in East Gippsland have also proved the existence of lignites above Miocene marine strata, showing that the lignites are not limited to one horizon. In the Parish of Glencoe, some 30-35 miles east of Yallourn, logs of bores show the presence of lignite, 70 feet in thickness, beneath the earliest marine beds at depths of from 1,200 to 1,400 feet. It is quite possible that these lignites are directly connected with the lowermost freshwater beds at Morwell, but that does not mean that the whole of the Yallournian series dips below the oldest of the marine beds. The freshwater beds at Morwell and the marine beds in the Parish of Glencoe are still practically horizontal, and it is difficult to imagine how the former could dip under the latter as has been suggested by Singleton. There is, further, no proof that any marine strata have ever existed above the Morwell lignites; these latter are very hydrous, containing up to 60% of water, and they could hardly have retained that amount of water if they had ever been overlain by a thick series of marine beds.

The occurrence of lignites above marine strata of Miocene age, as well as their occurrence below them, shows that there is an interdigitation of marine and freshwater beds in this part of Victoria, and it would appear probable that a continuous deposition of freshwater beds was going on at Morwell simultaneously with the deposition of marine strata elsewhere. The thickness of the Yallournian at Morwell is similar to that of the marine series in East Gippsland, and the deposition of the one would surely demand at least as great a period of time as that of the other.

With these facts in view there would seem to be no reason why the topmost beds at Yallourn, which contain the fossil plants, might not be as young as Lower Pliocene in age. It might also be noted that H. Herman (1922) states that "the



great mass of the Latrobe Valley brown coals appear to be stratigraphically superior to extensive sheets of the 'Older Basalt'".

(f) *Berwick*.—This locality lies some distance to the west of Morwell, and here again fluviatile beds containing fossil leaves are found underlying basalts, both resting upon Lower Palaeozoic strata. The basalts have been referred to the Older Basalt Series, but the only proof of their age is the underlying fossil plants which are listed in Table I, which were described by H. Deane (1902).

## II. Western Victoria.

Basalt-covered fluviatile deposits similar in character to those just described are extensively developed in Western Victoria.

A. *Bacchus Marsh*.—This lies at the eastern margin of the Ballarat Tableland and there occurs here a series of fluviatile deposits underlying the Newer Basalts which have been described by R. Brough Smyth (1874) as follows: "At Bacchus Marsh conglomerates, sandy clays and beds of ironstone ranging up to 200 feet in thickness are seen overlying an older volcanic rock such as that occurring at Melbourne, Flemington, etc. The ironstone bands and ferruginous sandstones are full of the impressions of dicotyledonous leaves." The fossil leaves that have been described are listed in Table I. These freshwater beds are in turn overlain by basalts (Newer Basalts).

An excellent account of the physiography of this area has been published by C. Fenner (1918).

B. *The Ballarat District*.—The geology and physiography of this region have been described in detail by H. Baragwanath (1923); he shows it to consist of a tableland with an elevation of 1,500-1,600 feet, the surface being a peneplain cut out of Lower Palaeozoic formations. Incised into the surface of this peneplain is a series of broad valleys up to 500 feet in depth which are almost filled with a succession of fluviatile deposits and lava flows (see Figure 5). At Ballarat, above the lowest gravels, there are found four basalt-flows with interstratified fluviatile deposits. Subsequently to the outpouring of these basalts, a series of wide shallow mature valleys were cut out alike in the basalt and older rocks. At Haddon (Smyth, 1874) the lead underlying the basalt has yielded fossil fruits and fossil leaves, while at Guildford (Smyth, 1875) specimens of both fossil leaves and fossil fruits have been obtained from a lead in the Meins Freehold Goldmining Co. property, Guildford, at a depth of 198 feet below the surface (Smyth, 1874).

C. *Pitfield*.—This occurs on the southern margin of the Ballarat District and here the fluviatile deposits and their associated basalts rest upon marine strata of Tertiary age. These conditions at this locality have been described by Stanley Hunter who wrote (1909) as follows: "Bores put down show that there are three distinct flows of basalt; between the 1st and 2nd flows lay lignitiferous clays containing Tertiary leaves, between the 2nd and 3rd flows was wash similar to that taken out elsewhere at Pitfield and which Mr. E. Lidgley considers to be L. Pliocene." Hunter states further that the bores passed a foot or so into underlying marine beds of supposed Eocene age, but the age of these marine beds has since been determined by F. A. Singleton (1935) as being Lower Miocene. The fossil leaves referred to have been described by Henry Deane (1902) and are listed in Table I.

It will be seen from the descriptions given that the fluviatile deposits and associated basalts of Western Victoria (Bacchus Marsh, Ballarat and Pitfield) are quite similar in their nature and mode of occurrence to those of Eastern Victoria

(Dargo, Aberfeldy, Tangil and Narracan), that both regions have yielded a similar fossil flora (leaves and fruits), and that in both regions the physiographic setting is the same, and this surely is sufficient evidence for considering them to be of the same geological age. Yet most observers have considered those of Eastern Victoria to be of Lower Tertiary age and those of Western Victoria to be of Upper Tertiary age.

It is also obvious from the descriptions given that the Tertiary fluvial deposits of New South Wales, with their associated basalts, are similar in every way to those of Victoria. The one point of real difference between the various localities in both States is the elevation at which they stand to-day; both the geological and the physiographical evidence indicate that these Tertiary deposits were laid down on a peneplain elevated only a few hundreds of feet above sea-level and that, subsequent to their deposition, both peneplain and Tertiary deposits were elevated to form the present-day tablelands—probably at the close of the Tertiary Era; the fact that the elevation was a differential one accounts for the present difference in elevation at the various localities which have been described. The high altitude of the Tertiary formations on the Dargo High Plains (6,000 feet), together with the profound gorges which surround them, may have suggested to some of the earlier workers a high geological antiquity as compared with the Ballarat occurrences, where dissection, owing to the lower elevation (1,600 feet), is not so striking, but the difference is only one of altitude; the dissection of the Ballarat Tableland at Bacchus Marsh is at a similar stage of development to that of the Dargo High Plains. One concludes, therefore, that the Tertiary formations of New South Wales and those of Eastern and Western Victoria described here are all of one and the same geological age.

#### *The Cainozoic Fossil Flora.*

From the fluvial deposits described in the last section there has been obtained a number of fossil plants, including (a) fossil leaves, (b) fossil fruits; the latter have been obtained from the coarse gravels at or near the base of the deposits, while the fossil leaves have been obtained from beds of clay overlying the gravels. The leaves and fruits have rarely both been obtained from the same leads.

(a) *The Fossil Leaves.*—A large number of fossil leaves obtained from (1) the Emmaville District and (2) the Dalton District have been described by Ettingshausen (1888), and were considered by him to be of Eocene age. Ettingshausen considered these fossil plants to represent a mixed flora consisting partly of species related to plants still living in Australia and partly of genera and species whose nearest allies were to be found in fossil plants from countries other than Australia. Among the former he described species of *Callitris*, *Dammara*, *Phyllocladus*, *Casuarina*, *Santalum*, *Persoonia*, *Grevillea*, *Hakea*, *Lomatia*, *Dryandra*, *Caricoma*, *Ceratopetalum*, *Boronia* and *Eucalyptus*, and considered these to be more or less closely related to living Australian forms. With regard to those he considered to be foreign, he referred them to such genera as *Sequoia*, *Myrica*, *Alnus*, *Quercus*, *Cinnamomum*, *Sassafras*, *Araha*, *Eleocarpus*, *Acer* and *Copaifera*, and considered the nearest relations of some of them to be species found in Europe and America, with geological ages varying from Cretaceous to Miocene; it is upon this evidence apparently that he gives an Eocene age to these fossils.

Ettingshausen's determinations have been severely criticized by Henry Deane, who (1896) wrote as follows: "I have carefully looked into the matter of the

Dalton and Vegetable Creek fossils, and I cannot agree with the crucial determinations as to the character of the flora, and its resemblances to the flora of other parts of the world are utterly wrong. With the aid of R. T. Baker I have made comparisons with the fossil leaves and living ones, and so far as I have gone the various types of fossil leaves are represented among existing plants and there is no need to go outside Australia to look for them." In his paper Deane gives examples of some of what he considers to be Ettingshausen's faulty determinations, and points out that all or nearly all of the fossil leaves described possess the form and character of existing plants living in the "brush forests" of Eastern Australia.

Deane (1900) returns to the attack after he had made a study of the fossil leaves from Vegetable Creek (Emmaville), Gunning, Wingello and Bacchus Marsh (Victoria), and reaffirms his previous view that all of the species are closely related to existing Australian plants. He draws attention to the difficulty of determining which existing plant a particular fossil leaf really resembles, and states that it may resemble those of half a dozen plants belonging to widely different groups.

R. H. Walcott (1920) has also questioned the value of these fossil leaves as an evidence of geological age, and states that "when living species are never determined by leaves alone, notwithstanding that they may be procured in abundance and in perfect condition, it seems to be rather unwise for stratigraphical purposes to place too much reliance upon specific determinations made from the examination of perhaps imperfect fossil leaves or specimens of wood in various conditions of preservation".

The above criticisms not only apply to Ettingshausen's determinations of New South Wales fossil leaves, but apply equally to McCoy's determinations of geologic age of similar fossil leaves obtained from the deep-leads of Victoria, determinations which are apparently still being adhered to by workers in that State. It is worthy of note that Baron von Mueller, one of the most eminent botanists of his day, always refused to have anything to do with the determination of fossil leaves.

In view of the above facts, the decisions of both Ettingshausen and McCoy as to the Eocene-Lower Miocene age of the Australian Tertiary fossil leaves cannot be accepted as reliable and, in view of the evidence put forward by Deane that they are closely related to forms still living in the "brush forests" of to-day, it is quite possible that they are no older than Pliocene in age.

Henry Deane, in criticizing the determinations of Ettingshausen and McCoy, did not carry his views to their logical conclusion, because when he later described some Tertiary fossil leaves from New South Wales and Victoria he referred them to the Lower Tertiary. Deane as a botanist was primarily concerned with the correct botanical classification of his specimens and apparently accepted the views of the geologists of his day as to the Lower Tertiary age of the leads without question, apparently overlooking the fact that their opinions as to age, at least with regard to some of the leads, had been based on McCoy's determinations of the Lower Miocene age of the fossil plants.

(b) *The Fossil Fruits*.—These were described by von Mueller (1874) and considered by him to be of Pliocene age, and that determination has generally been accepted by later writers. Some confusion of thought has been brought about by the fact that fossil leaves and fossil fruits have usually not been found in one and the same lead, and this has been accepted as further proof that the

leads containing the fossil leaves were geologically older than those containing the fossil fruits. However, both fossil leaves and fossil fruits have been recorded as having been obtained from some of the leads in the Ballarat district. Fossil leaves and fossil fruits have also been obtained from the same deposit at Sandy Bay, near Hobart, Tasmania (Wilkinson, 1882), and their association at other localities in Tasmania has been recorded by R. M. Johnston (1879).

There is a possible explanation as to why both leaves and fruits are not usually found together. Records show that the fossil fruits have usually been obtained from the coarse gravels in the deepest part of the old river-channel, conditions quite unsuitable for the preservation of leaves; these gravels are usually highly charged with water, conditions which seem to have been particularly favourable for the preservation of the fruits, because when such fossil fruits are removed from the leads they quickly disintegrate unless preserved under water or some other liquid; at any rate that has been the writer's experience. The fossil leaves, on the other hand, have usually been obtained from beds of fine sediment situated some distance above the main gutter in which the gravels occur, conditions which may not be entirely favourable for the preservation of the fruits.

In the Ballarat District of Victoria fossil fruits and leaves have been obtained from the Haddon Lead, whereas fossil leaves only have been found in the leads at Pitfield; both series of leads occur under the same series of basalts (the Newer Basalts) and are undoubtedly of the same geological age. Fossil leaves have also been obtained from the fluviatile deposits which occur under the Newer Basalts at Bacchus Marsh, and these beds have always been considered to be of Pliocene age. Similarly, in Eastern Victoria fossil fruits have been obtained from the Tangil Lead, whereas fossil leaves have been obtained from the fluviatile beds at Narracan, in both cases under the same series of basalts, but these basalts have always in the past been referred to the older basalt series (Older Basalts) considered to be of Oligocene or Lower Miocene age, apparently on the evidence of the fossil leaves. It seems quite certain that the fluviatile beds of Tangil and Narracan are of the same geological age.

R. A. Murray (1880) came up against this difficulty when describing the Tangil Lead, and made the following remarks: "It may be noted that some of the species of fossil fruits described by Baron von Müller are common to both Miocene and Pliocene drift, specimens having been found in the gravels beneath the Older Basalt at Tangil precisely identical in species with some obtained from the lead gravels beneath the Newer Basalt at Haddon." Smyth (1874) had previously referred the basalts at Tangil to the Newer Basalts, and had correlated the underlying leads with the leaf-beds at Bacchus Marsh; but Murray referred the Tangil basalts to the Older Basalts because their mode of occurrence and the physiography of the surrounding country resembled that of the basalts of the Dargo and Bogong Plains, which were and are still considered in Victoria to be Older Basalts, presumably because of McCoy's determination of the Lower Miocene age of the underlying plant beds.

Fossil leaves have been described from a number of localities in Victoria, the more important of which are tabulated below; in this table the names of the genera only are given, as the writer places very little reliance upon the determinations of species from such material; however, had the species also been given it would have made very little difference to the result. Those of the Victorian genera which have been recorded also for New South Wales are indicated in the right-hand column.

TABLE I.—*Fossil Leaves recorded from Victoria.*

	Dargo.	Narracan.	Morwell.	Berwick.	Bacchus Marsh.	Pitfield.	N.S.W.
<i>Cinnamomum</i> .....	X	X	X	—	X	X	X
<i>Laurus</i> .....	X	—	—	—	X	—	X
<i>Ficus</i> .....	X	—	—	—	—	—	X
<i>Lastra</i> .....	X	—	—	—	—	—	—
<i>Eucalyptus</i> .....	X	X	—	X	—	X	X
<i>Sterculia</i> .....	—	X	—	—	X	X	—
<i>Tristanites</i> .....	—	X	—	X	—	—	—
<i>Hedycarya</i> .....	—	X	—	X	—	—	X
<i>Mollenedia</i> .....	—	X	—	X	—	X	—
<i>Ficonium</i> .....	—	X	—	—	—	—	X
<i>Nothofagus</i> .....	—	X	—	X	—	—	X
<i>Argophyllites</i> .....	—	—	—	—	—	X	X
<i>Daphnandra</i> .....	—	—	—	X	—	X	—
<i>Carpolithes</i> .....	—	—	—	X	—	X	X
<i>Eucryphia</i> .....	—	—	—	—	—	X	—
<i>Nephelites</i> .....	—	—	—	X	—	X	X
<i>Panacites</i> .....	—	—	—	X	—	X	—
<i>Pittosporum</i> .....	—	—	—	—	—	X	X
<i>Lomatia</i> .....	—	—	X	X	—	—	X
<i>Phyllites</i> .....	—	—	—	X	—	—	X
<i>Apocynophyllum</i> ..	—	—	—	X	—	—	X
<i>Banksia</i> .....	—	—	X	—	—	—	X
<i>Dryandra</i> .....	—	—	X	—	—	—	—
<i>Ginkgo</i> .....	—	—	X	—	—	—	—
<i>Phyllocladus</i> .....	—	—	X	—	—	—	—

After allowing for incomplete collecting, particularly from some of the localities, there would seem to be little doubt that these genera all belong to one and the same Tertiary flora, a view which appears to be generally accepted. As the genus *Cinnamomum* appears to be the most widespread of these genera, it will be convenient to refer to this flora as the *Cinnamomum* Flora.

It has already been shown that there is strong evidence in favour of the belief that both the fossil fruits and the fossil leaves have been derived from deposits of the same geological age; the fossil fruits were referred by Baron von Mueller to the Lower Pliocene, and a Pliocene age has since been generally accepted for them; the fossil leaves, on the other hand, have been given ages ranging from Eocene to Pliocene, according to the locality from which they have been obtained; those found under basalts believed to belong to the Older Basalt series were considered to be Oligocene or Lower Miocene in age, whereas those occurring under basalts believed to belong to the Newer Basalt Series were considered to be Pliocene in age. The value of the comparisons made by Ettingshausen and McCoy with plants of Cretaceous, Eocene and Miocene ages in other continents is very doubtful. Henry Deane has repeatedly referred to the close resemblance of these fossil plants to plants living in our present-day "brush forests", and there appears to be no reason, therefore, why these fossil leaves may not be as young as Lower Pliocene, that is, the same age as has generally been accepted for the fossil fruits; other evidence in support of this will be referred to later.

#### *The Marine Formations of New South Wales.*

Strata of marine origin are limited in New South Wales to a small area in the south-western corner of the State; they do not outcrop at the surface, being covered by more recent deposits, and such knowledge as we have of them is limited to information obtained from bore-holes put down in search of artesian water. A bore-hole at Arumpo has penetrated these beds to a depth of 647 feet, showing that they are upwards of 600 feet in thickness.

The Marine formations of Tertiary age in Australia have been classified by Messrs. Chapman and Singleton (1923) as follows:

Upper Pliocene—Werrikoolan Series.

Lower Pliocene—Kallimnan Series.

Upper Miocene—poorly developed.

Middle Miocene—polyzoal limestones of E. Gippsland.

Lower Miocene—Janjukian Series (and Barwonian Series).

Upper Oligocene—Balcombian Series.

The marine strata of south-western New South Wales have been referred by Chapman and Singleton mainly to the Janjukian, extending perhaps into the lower part of the Kallimnan Series.

*Relation of the Terrestrial and Marine Formations.*

In view of the unsatisfactory evidence of geological age afforded by the Tertiary fossil plants, it becomes necessary to find out what evidence can be obtained from the association of the terrestrial formations with the Tertiary marine beds.

No association of terrestrial and marine formations has been found so far in New South Wales, but fortunately the two have been found in association at several localities in Victoria.

(a) *Pitfield Plains*.—The conditions at this locality have already been described, and it has been shown that the fluviatile deposits containing fossil leaves and the associated lava-flows overlie marine strata of Janjukian age (Lower Miocene); obviously here the former are younger than the latter, but the question is how much younger? The fluviatile deposits could not have been deposited in the sea, and it would appear to be obvious that subsequent to their deposition the marine deposits must have been elevated and the sea-bed converted into dry land before the fluviatile beds were deposited. At no very great distance to the north, on the Ballarat Tableland, similar fluviatile deposits and their associated basaltic lava flows were deposited in definite valleys ranging up to 500 feet in depth, incised into an uplifted peneplain; it is not unreasonable to assume that these valleys continued southwards into the uplifted marine strata at Pitfield Plains and that the fluviatile beds, therefore, were deposited in actual valleys, not necessarily as deep as those at Ballarat. If this supposition is correct it implies that a considerable interval, accompanied by uplift and subsequent denudation, elapsed between the deposition respectively of the marine strata and the fluviatile strata. Support for this view is supplied by geological sections in the valley of the Moorabool River some distance to the east of Pitfield Plains. The geology of this region has been described by Hall and Pritchard (1897), who, in their geological sections, show the Newer Basalts, the same basalts as those occurring at Pitfield Plains, resting unconformably upon an eroded surface of the underlying Janjukian marine beds.

The evidence from these two localities shows that the leaf-bearing fluviatile deposits and their associated lava flows are definitely younger than Lower Miocene and quite possibly as young as Pliocene.

(b) *The Hamilton District*.—The Newer Basalts of the Ballarat Tableland continue westwards without a break to the Hamilton District, where they cap a tableland about 600 feet in altitude, the tableland having a gentle tilt from Ballarat (1,600 feet) westwards to Hamilton (600 feet). At Hamilton the basalts show the same deep weathering and the same mature dissection as they do at Ballarat, but here they rest directly upon marine strata.

The marine strata consist of Janjukian beds capped by a few feet only of Kalimnan marine beds, and the latter are capped in turn by the Newer Basalts. The nature of the contact between the two latter formations is not very clear in the field, but the evidence suggests that the Kalimnan sedimentation was interrupted by the pouring out of the basaltic lavas over the sea-bottom; it is, however, possible that some erosion of the marine beds may have taken place before the extrusion of the basalts. However, one fact is quite clear, and that is that the basalts cannot be older than Lower Pliocene.

Besides the Newer Basalts just referred to, there occurs in this district a still younger series of basaltic lava flows which have always in the past been grouped under the term Newer Basalts. At Byaduk, some few miles south of Hamilton, these younger basalts may be seen as flows partly filling the mature valleys which occur on the surface of the tableland. The Newer Basalts proper, in which the mature valleys occur, are deeply weathered, the ridges between the mature valleys are gently rounded, while rock outcrops are few and inconspicuous. The still younger basalt flows which lie in, and have flowed down, the mature valleys are but little weathered, there is very little soil, and consequently very little vegetation on their surfaces, and typical lava tunnels exist underneath them. When viewed from a short distance they give the impression of having flowed down the valley only a few years ago.

From the description just given it will be obvious that quite a long erosion interval exists between these two series of basalts, and the younger cannot be older than Pleistocene and may even be Recent in age.

*Drik-Drik District.*—The basalt-capped tableland extends south-westwards from Hamilton to the Glenelg River and has here an elevation of about 500 feet, the basalts themselves being about 250 feet in thickness. The writer is indebted to Mr. R. A. Keble for the details of the geology of this district; he states that the present-day valley of the Glenelg River is younger than the basalt which caps the tableland and that this valley, since its first formation, has been partly submerged beneath the sea and later uplifted; during the submergence, marine strata of Werrikoolan (Upper Pliocene) age were deposited in it and such strata are, therefore, younger than the basalts. The succession of events as given by Mr. Keble was as follows:

1. Extrusion of the basalts (Newer Basalts) which covered the ancient valley of the Glenelg River.
2. Initial erosion of the present Glenelg Valley at the fringe of the basalt sheet.
3. Submergence followed by the deposition of marine strata of Werrikoolan age.
4. Uplift bringing the Glenelg Valley again above sea-level.

This evidence gives an upward limit to the age of the Newer Basalts; they are pre-Werrikoolan.

From the evidence at Pitfield Plains, Moorabool River, Hamilton and Drik-Drik, it seems quite certain, therefore, that the Newer Basalts of Western Victoria and their associated fluvial beds containing fossil leaves and fossil fruits are of Pliocene age, and most probably of Lower Pliocene age.

Having considered the upward limit of age of the *Cinnamomum* flora, attention should now be given as to what evidence there may be as to its downward limit of age.

F. A. Singleton (1935), in referring to the occurrence of the genus *Cinnamomum* in the upper series of the marine beds at Beaumaris (Victoria),

states that these beds have usually been referred to the Kalimnan (Lower Pliocene), but gives some reasons for thinking that they may be Upper Miocene; even if this suggestion should prove to be correct, it does not bring the genus *Cinnamomum* lower than Upper Miocene.

At Sentinel Rock (Victoria) leaf-bearing beds overlie marine strata of Barwonian (Lower to Middle Miocene) age. F. Chapman (1905) states that "this flora is a very distinct one, the leaves being chiefly of the *Coprosma* (*Coprosomophyllum* Hy. Deane) type; other genera present are the proteaceous *Persoonia*, the coniferous *Phyllocladus*; *Casuarina* and *Acacia* are also present". This flora is certainly not the typical *Cinnamomum* flora, but in any case, resting as it does upon marine Barwonian strata, it cannot be older than Upper Miocene and may even be younger.

At Moorlands in South Australia (Mawson and Chapman, 1921) fossil plants have been found occurring below marine Miocene strata, but only two genera have been described, a *Hanksia* and a *Telopea*; this again is not the typical *Cinnamomum* flora.

More recently some fossil leaves have been found by Sir Douglas Mawson in clay beds lying beneath marine strata of Janjukian age at Blanche Point, Aldinga, in South Australia. These have been described by F. Chapman (1935), and include the genera *Ficuntum*, *Pomaderris*, cf. *Banksia*, *Eleocarpus*, *Sterculia*, similar, according to Chapman, to species occurring in the *Cinnamomum* flora, but as to whether these few fossil plants truly represent the *Cinnamomum* flora is a matter for question.

From the Redbank Plains in south-eastern Queensland a fossil flora has been found which includes the genera *Sapindus*, *Ficus*, *Myrica*, *Banksia*, *Cinnamomum*, *Diemenia*, *Eucalyptus* and *Apocynophyllum*, and there would appear to be no doubt that it is a similar flora to the *Cinnamomum* flora of New South Wales and Victoria. These same beds have yielded fossil fish which have been described by E. S. Hills (1934); he has described four species, all new ones, as follows:

- (a) *Epiceratodus denticulatus*, which Hills considers to be very close to *E. forsteri*, a species which ranges from Pleistocene to Recent;
- (b) *Phareodus queenslandicus*.—Hills states that the only other known occurrences of this genus are in the Eocene of Wyoming and the Lower Tertiary of Java; the Queensland example is, however, a new species;
- (c) *Notogoneus parvus*.—The only other known fossils of this genus are stated to range from Eocene to Oligocene. Hills, however, was doubtful as to whether his Queensland specimens were really referable to *Notogoneus*, and states that "better material may reveal differences sufficient to separate from this genus";
- (d) *Percalates antiquus*.—Hills's conclusion was that there is an extremely close resemblance between this species and the living *P. colonum*.

It is obvious that the evidence of age given by these fossil fish is somewhat conflicting; this was realized by Hills, and he referred them tentatively to the Oligocene Period; the question may well be raised as to whether a younger age is not suggested by these fossil fish in view of the fact that two of them are very closely related to Pleistocene and living species, while, of the other two, one is a new species, and of the other the true genus is in doubt.

From the above it will be seen that although some few fossil leaves have been found in undoubted pre-Miocene strata, there is at present no certain evidence, from association with marine strata, that the *Cinnamomum* flora as a



whole is older than Lower Pliocene, while so far as the evidence of the associated fossil fish in south-eastern Queensland is concerned, while it cannot be ignored, it is at least doubtful. It is quite certain, of course, that some of the members of this flora existed in pre-Pliocene times; perhaps they all did; but the only thing that we can be really sure about at present is that this flora was abundant and widespread in Pliocene times.

Reference should be made here to an association of marine strata with an auriferous lead at the Welcome Rush near Stawell (Victoria). This occurrence was first described by R. Brough Smyth in a letter to the *Geological Magazine*; he stated that marine fossils had been obtained from a bed of ferruginous material about thirty-eight feet below the surface of the ground and forty feet above the Silurian bedrock upon which the auriferous wash rests. The few marine fossils found here were described by F. McCoy, who referred them to the Lower Pliocene. These fossils, which are few in number and most of them poorly preserved, have since been re-described by F. Chapman (1905), who concluded that "they represented a horizon near the summit of the Janjukian Series, but older than the Kalimnan (Lower Pliocene) and younger than the Balcombian"; that is, about Middle Miocene in age.

The strata associated with the auriferous gravels have not yielded any fossil leaves or fossil fruits, and they do not appear to be associated with any of the Tertiary Basalts; consequently there is nothing to enable any correlation to be made with other Victorian fluviatile deposits, and they do not, therefore, afford any direct evidence as to the geological age of the latter.

#### *The Volcanic Rocks of New South Wales.*

The Cainozoic volcanic rocks of New South Wales were described in some detail by the writer (1923), and there is no need to add here to that description; they were classified as follows:

The Alkaline Series—Late Tertiary.

The Plateau Basalts—Lower Pliocene.

The Monadnock Basalts—Upper Cretaceous or Eocene.

(a) *The Monadnock Basalts.*—These occur as cappings on some of the physiological residuals (monadnocks) rising above the level of the adjacent tablelands; the areas covered are relatively small.

(b) *The Plateau Basalts.*—These are the basalts covering extensive areas of the surfaces of the present-day tablelands and which in places overlie the fluviatile deposits already described. The term plateau basalt was used in a purely geographical sense and was a very convenient one, but of late years this name has, unwisely, been given a petrological significance which does not necessarily apply to all basalts situated on tablelands. Reasons have already been given for referring these basalts to the Lower Pliocene.

(c) *The Alkaline Series.*—These consist mainly of alkaline rocks ranging from acid to basic in composition and include some basalts. The areas occupied are relatively small.

The Cainozoic Volcanic Rocks were later referred to in some detail by Dr. W. R. Browne (1933), who differed from the writer on a number of points; the most important difference being with regard to the age of the Alkaline Series; these he considers to be older than the Plateau Basalts; these differences will not be discussed here, but will form the subject later of a separate paper. Dr. Browne drew attention in his paper to one very interesting occurrence in the

Moruya District of New South Wales, where Dr. Ida Brown had noted the occurrence of basalts overlying beds of coarse grit containing fragments of pelecypods, which F. A. Singleton had tentatively referred to the Upper Cainozoic.

*The Cainozoic Volcanic Rocks of Victoria.*

These have in the past been classified as follows, and a summary of their occurrence has been published by E. W. Skeats (1909):

1. The Alkaline Series—Middle Cainozoic.
2. The Newer Basalts—Pliocene to Pleistocene.
3. The Older Basalts—Oligocene or Miocene.

*The Older Basalts.*—In south central Victoria, but particularly in the districts around and adjacent to Port Phillip, basalts occur which definitely underlie marine strata of Lower Miocene age. In summarizing these occurrences, F. A. Singleton states "that basalts have been found beneath Jaujukian limestone at Airey's Inlet; beneath *Lepidocyclina* limestone at Flinders and Keilor; beneath Balcombian marls at Balcombe Bay, and under beds of probably similar age at Curlewis and Royal Park". He considers these basalts to be Oligocene in age, since they underlie the marine beds unconformably. It was to occurrences such as these that the term "older basalts" was originally applied; there can, of course, be no doubt as to their Lower Cainozoic age. Unfortunately, there has later been grouped with them a series of basalts in Eastern Victoria which are not associated with marine strata; these include the occurrences already described as occurring at Dargo High Plains, Aberfeldy, Tangil, Narracan, Berwick, etc. The correlation of these occurrences with the Older Basalts was apparently based upon McCoy's determination of the Lower Miocene age of the fossil plants found under the basalts at Dargo High Plains, but, as has already been pointed out in an earlier part of this address, it is much more probable that these plants are of Lower Pliocene age, and, if this is correct, the basalts cannot be older than Lower Pliocene.

One interesting example of basalts of two distinct ages occurs at Aberfeldy. The geology of this district has been described by Mr. Baragwanath (1925); he describes the existence of two peneplains, an older one now surviving only in the form of residuals, of which Mt. Useful (4,760 feet) is one, and a younger one now forming the surface of the existing tableland whose altitude near Mt. Useful is about 3,500 feet. A basalt capping overlying what Mr. Baragwanath calls peneplain gravels and which is therefore part of a one-time lava flow, occurs on top of Mt. Useful, that is, on the older peneplain; basalts also occur on the surface of the present tableland (with underlying river gravels), that is, on the surface of the younger peneplain—this basalt was also a lava flow. It is obvious that the basalt on top of Mt. Useful must be much older geologically than that on the tableland below; the former would correspond with the Monadnock basalts of New South Wales, while the latter would correspond with the Plateau basalts of New South Wales. The possible age of the Mt. Useful basalt will be discussed later.

Under the term "older basalt" has also been included a flow which occurs interstratified with Miocene marine strata at Maude in the Moorabool Valley (Hall and Pritchard, 1895); this flow cannot be older than Lower Miocene.

It appears, therefore, that basalts of three distinct ages, Oligocene, Lower Miocene and Lower Pliocene, have been grouped together under the term "Older Basalts".

*The Newer Basalts.*—This term has been used to include the whole of the basalts occurring in Western Victoria, and the age given by most writers has been Pliocene to Pleistocene. In this region there are basalts of at least two distinct geological ages, the two being separated by a wide erosion interval. The older series is that which occurs in the more northern part of the area, and forms a capping to the low tableland which extends from Bacchus Marsh to the Glenelg River. These basalts have already been referred to in the description of the fluvialite deposits which in places underlie, or are interstratified with, them and reasons advanced for considering them to be of Lower Pliocene age.

It has been pointed out by E. W. Skeats (1909) that wide mature valleys have been incised in the surface of these basalts, and by the writer that at Byaduk younger basalts have flowed down and partly filled these mature valleys, and that these younger basalts cannot be older than late Pleistocene and may even be as young as Recent in age. F. A. Singleton (1935) has referred to the existence at Portland, in the far west of Victoria, of basalts overlying oyster beds of Werrikoolan (latest Pliocene) age; these basalts are probably also of Pleistocene age. In the southern part of Western Victoria, particularly in the Colac and Camperdown districts, there is an extensive development of basaltic lava flows, beds of tuff and tuff cones. F. A. Singleton (1935) states that because of their state of preservation these cannot be older than Upper Pleistocene; the writer has visited this area and would go so far as to say that the vulcanicity may even have continued into Recent times.

The newer basalts of Western Victoria, therefore, include (a) basalts of Lower Pliocene age, and (b) basalts of Pleistocene age, perhaps extending into the Recent Period.

*The Alkaline Series.*—These have only a very limited distribution and were originally referred by Prof. E. W. Skeats (1909) to the Middle Cainozoic, but more recently F. A. Singleton (1935) has referred them to the Late Pliocene or Pleistocene.

It will be seen, therefore, that the basalts of Victoria apparently belong to at least four distinct geological periods, (a) Oligocene, (b) Lower Miocene, (c) Lower Pliocene, (d) Pleistocene to Recent. Under these circumstances the use of the terms Older and Newer Basalts is misleading, and has led to much confusion, and it would be better if both terms were dropped.

*The Existing Topography of New South Wales and its Development.*

No part of the State of New South Wales, except one small area in the south-western corner, has been beneath the sea since the close of the Mesozoic Era, while the greater part of it has not been beneath the sea since the close of the Palaeozoic Era; the present topography, therefore, has been in course of development since at least as far back as the Cretaceous Period.

It is not necessary to give here a detailed account of the existing topography; that has already been fully done by E. C. Andrews (1910), and nothing has been published since which necessitates any serious modification of the views put forward by him. It will be necessary, however, to refer to the more important features for the purpose of showing their relation to such Cainozoic geological formations as do occur; it will also be necessary to correlate the physiographical features of New South Wales with those of Victoria.

The greater part of New South Wales to-day consists of tablelands with altitudes ranging from as low as a few hundred to as high as 6,000 feet or more; the exceptions to this generalization are the extensive alluvial plains which exist

in the north-western and south-western parts of the State; similar tablelands extend northwards into Queensland and southwards into Victoria. The original surfaces of these tablelands were all parts of a great peneplain (the Great East Australian Peneplain), developed probably during Lower Tertiary time and elevated to form the existing tablelands at the close of the Cainozoic Era (the Kosciusko Uplift). Since their uplift the tablelands have suffered considerable dissection, particularly along their eastern and western margins, but there still remain to-day extensive areas, particularly adjacent to the Main Divide, which are still undissected; these undissected tableland remnants give us a picture of the late Cainozoic land surface, as it existed before the uplift took place, and provide evidence which helps us to interpret the geological history of that Era.

An ideal section across such a tableland remnant is given in Figure 6; it shows the general level of the peneplain surface, above which rise residuals of the older tableland out of which the peneplain was cut. In any one district the more important of these residuals all rise to approximately the same altitude above the peneplain surface, and this gives some measure (minimum, of course) of the altitude of the older tableland. The altitude of these residuals varies from district to district, ranging from 450 feet to 1,500 feet. It is highly probable, of course, that the surface of this older tableland was also a peneplain, and this older peneplain, now almost completely destroyed, was probably developed during the Cretaceous Period, and may be tentatively referred to as the Cretaceous Peneplain, while its successor, which forms the surface of the present tablelands, may for convenience be referred to as the Lower Tertiary Peneplain.

In some districts, notably the Blue Mountain Tableland, the residuals above referred to are capped with basalt, and in some cases river gravels underlie these basalts.

When the surfaces of the present-day tablelands are studied in detail it is found that the original peneplain surfaces have undergone certain modifications as shown in Figure 2; it is found that, after its development, stream channels were incised in its surfaces to depths ranging from 300 to 400 feet; for this to have been possible an uplift of 300 to 400 feet must have taken place. Owing to some change in conditions active erosion in these stream channels gave place to aggradation and they became partly filled with deposits of sand, clay and lignite. This was followed in many districts by the outpouring of extensive flows of basalt which covered up the fluvial deposits, partly filled the already formed valleys in some cases, and in others completely filled them and overflowed on to the peneplain surface. After the volcanic outbursts ceased, erosion continued and resulted in the production of a network of broad mature valleys over the peneplain surface, cut alike out of the basalts and the older rocks; these valleys range up to 400 feet in depth and up to several miles in width and are separated from one another by gently rounded ridges, but in places moderate areas of the original peneplain surface still survive. Such an extensive development of wide mature valleys in an area of low relief (300 to 400 feet) must have required an extensive period of time, amounting almost to a cycle of erosion. This incomplete cycle of erosion was terminated by the uplift which produced the present-day tablelands, and which elevated the system of mature valleys to their present high altitude; because of their elevated position E. C. Andrews has referred to them as the "Upland Valleys". At the present time the floors of these old Cainozoic valleys are aggraded and no active erosion is taking place, but in many places the gorges of the present cycle of erosion can be seen heading back along them, and in such

places, of course, the valleys are being deepened and active erosion is taking place.

For the production of a topography such as has just been described the following succession of events would be necessary:

1. A cycle of erosion which produced the older peneplain (the ? Cretaceous Peneplain);
2. An uplift of from 450 to 1,500 feet which converted this peneplain into a series of tablelands;
3. A second cycle of erosion which produced the Lower Tertiary Peneplain (Great East Australian Peneplain);
4. An uplift of from 300 to 400 feet producing low tablelands;
5. An incomplete cycle of erosion which produced the system of mature valleys (the Upland Valleys) and which was accompanied by extensive volcanic activity;
6. The Kosciuszko Uplift which produced the existing tablelands of Eastern Australia.

#### *The Geomorphology of Victoria.*

It is not proposed to attempt here a detailed account of the geomorphology of Victoria, but merely to outline sufficient of its more important features to make a comparison with that of New South Wales possible.

The most recent summary of the physiography of Victoria is that given by E. S. Hills (1935); in this he divides the State into a number of physiographic divisions with a general east-west trend; these divisions, starting from the north, are as follows:

- (a) The Murray Basin Plains province, a low-lying alluviated region lying to the north of the main belt of tablelands; this is similar to and continuous with the Riverina Plains of New South Wales;
- (b) The Western and Eastern Highland Provinces which together form an almost continuous belt of highlands lying along the main divide of the State;
- (c) A continuous belt of lowlands lying along the southern margins of the highland provinces; this is the region called by Professor Gregory the Great Valley of Victoria; much of it was covered by the sea during a considerable part of Tertiary time;
- (d) Two relatively small highland regions lying to the south of (c); the eastern one is called by Hills the South Gippsland Highlands, while the western one is referred to as the Otway Ranges.

The Eastern Highland Province ranges up to 6,000 feet in altitude, and at its eastern end joins up and is continuous with the Southern Tableland of New South Wales. Hills states that the dominant physiographic controls in these highlands are differential erosion, late Tertiary warp movements and Older Basalts; these latter he considers to be Oligocene to Miocene in age. He states that these flows filled pre-existing depressions and that, upon the elevation of the tableland and its subsequent dissection, they gave rise to lava residuals which occupy some of the highest land.

A description of the details of the physiography of a portion of this region called the Aberfeldy District by H. Baragwanath (1925) is very informative; he shows the presence there of two distinct peneplains, a younger one which forms the surface of the present-day tableland at an altitude of 3,000 to 3,500 feet and an older one now surviving in the form of residuals ranging from 1,000 to 1,500

feet above the general level of the tableland. These two erosion levels obviously correspond to the two peneplains which exist across the border in New South Wales. At Aberfeldy basalts occur on both peneplains; Baragwanath described a small area of basalt overlying gravels on the top of Mt. Useful (4,780 ft.), a part of the older peneplain and also the occurrence of basalts on the lower peneplain level, obviously lying in a valley eroded in that level; these two basalt occurrences are obviously of different ages and correspond to the Monadnock basalts and Plateau basalts respectively of New South Wales.

The maps and sections published by R. A. Murray of the Bogong and Dargo High Plains show the presence there, but at a higher altitude, of a peneplain corresponding to that of the younger one at Aberfeldy, also with its basalt-covered stream-channels.

The South Gippsland Highland has already been referred to in describing the fluvialite deposits at East Tangil and Narracan, and differs from the highland region to the north only in its lower elevation. Hills states that these highlands owe their elevation mainly to Pliocene earth movements, and that faulting was dominant during their uplift. The Western Highland Province has a much lower general altitude than the Eastern Province, ranging from a few hundred up to about 1,600 feet in altitude. Hills states that this province comprises ranges and valleys resulting from the differential erosion of a region of complex geology now partly buried beneath (?) Pliocene, Pleistocene and Recent basalts, and states further that prominent ranges rise above the general level of these highlands, such as Mt. Macedon, Mt. Brangor, Mt. Farrangower and the Grampian Mountains; these latter are considered by him to be residuals.

H. Baragwanath's description of the geology of the Ballarat District (1923) shows that the surface of the tableland there is a similar well-developed peneplain to that which occurs in Eastern Victoria, with similar valleys incised into its surface containing fluvialite deposits with similar fossil leaves and fruits and the whole partly covered by flows of basalt. The one important difference between the eastern and western province is that the latter does not show such striking dissection, but this is essentially a matter of altitude. The Western Tableland Province is highest along its eastern margin (about 1,600 feet in altitude), and here, for example at Bacchus Marsh, the dissection is relatively just as highly developed as in the Eastern Tablelands. In all other directions, but particularly westwards, this Western Highland Province is gently tilted and along its western margin the altitude has fallen to 500 feet or less; the streams which drain it have consequently relatively low grades and there has been no opportunity for the cutting out of deep gorges. The average rainfall of this western region also is much lower than that of the high tablelands in the Eastern Highland Province with a consequent smaller volume of water in the stream-channels.

The profound dissection of the Eastern Highland Province, together with the belief that the basalts capping the tablelands of that region were much older than those of the western province, seems to have led to the belief that the two regions have had a different physiographic history, but when one comes to analyse the essential features of the two regions there appears to be no real difference apart from that of altitude. In both regions the evidence shows (1) the presence of a well-developed peneplain, now forming the surface of the tablelands, (2) an elevation of this peneplain a few hundreds of feet followed by the cutting of shallow valleys into its surface, (3) the partial filling of these valleys by fluvialite deposits containing fossil leaves and fossil fruits, (4) outpouring of basalts covering the

fluvialite deposits, filling the valleys and in places overflowing on to the surrounding peneplain surface, (5) subsequent to the vulcanicity the development of wide shallow mature valleys alike in the basalts and older rocks, and (6) uplift to form the present tablelands.

The above is exactly the succession of events recorded along the whole of the tableland region of New South Wales.

The one important feature in which the Cainozoic history of Victoria differs from that of New South Wales was in the development of subsidence areas which allowed of marine sedimentation in such areas throughout a considerable part of Tertiary time.

#### *Summary.*

From the evidence presented, one gathers that the more important events of the geological history of the Cainozoic Era in New South Wales, including also something of the Cretaceous Period, were as listed below. This succession of events appears to hold good also for the Highlands of the State of Victoria. The suggested geological age for some of the items is, as will be pointed out later, only tentative.

1. (?) Cretaceous Period. A cycle of erosion which produced the older peneplain.
2. (?) Late Cretaceous or Early Eocene Period. The Monadnock Basalts.
3. Epi-Cretaceous. An epeirogenic uplift which uplifted the older peneplain and produced a series of tablelands ranging from 450 to 1,500 feet in altitude.
4. Eocene to Miocene. A cycle of erosion which produced the younger peneplain (Great East Australian Peneplain).
5. Epi-Miocene. An epeirogenic uplift which produced a series of low tablelands averaging about 400 feet in altitude.
6. Lower Pliocene. The erosion of valleys followed by the deposition in them of fluvialite deposits containing fossil leaves and fossil fruit.
7. Lower Pliocene. Widespread volcanic activity and outpouring of basalt flows over very wide areas.
8. Upper Pliocene. Continuation of valley formation with the ultimate development of a very widespread series of wide mature valleys—the Upland Valleys.
9. Late Pliocene. Pronounced epeirogenic uplift (the Kosciusko Uplift) with the production of the existing tablelands ranging up to 6,000 feet in altitude.
10. Pleistocene Period. A cycle of erosion which is still in operation and which has brought about the dissection of the existing tablelands.

The older peneplain has been, by most previous writers, referred to the Cretaceous Period; extensive marine sedimentation was going on during that period both to the west and to the east of the region now under discussion and some large areas of land must have been undergoing denudation to produce the sediments. The retreat of the sea from the Great Artesian Basin area and the folding of the marine Cretaceous sediments of Eastern Queensland show that pronounced earth movements occurred at the end of the Cretaceous Period; it seems quite reasonable to suppose, therefore, that a peneplain had been developed in Eastern Australia during the Cretaceous Period, and that it was elevated at the close of that period in what are now the tableland regions of Eastern Australia.

The Monadnock Basalts, lying as they do on the surface of the (?) Cretaceous peneplain, must be younger than that surface, and cannot, therefore, be older than the late Cretaceous, but if poured out after the uplift they might be early Eocene in age. They may possibly have some time relation to the basalts which underlie the marine Janjukian beds of Victoria, but there is no evidence in support of that available at present.

The cycle of erosion which produced the younger peneplain (the Great East Australian Peneplain) ended at or near the close of the Miocene Period, but the evidence as to just when it began is not so clear; quite possibly the epi-Cretaceous uplift initiated this cycle and it continued throughout Eocene and Miocene time, the development of the peneplain taking place more or less simultaneously with the sedimentation which was taking place in that area which was undergoing subsidence along the southern margin of Australia and in which the Oligocene and Miocene formations of Victoria and South Australia were deposited.

Sufficient evidence has already been given to show that events 6, 7 and 8 took place during the Pliocene Period and that a general uplift of the land followed at or about the close of this period. This great uplift, called by E. C. Andrews the Kosciuszko Uplift, was an epeirogenic one, varying from a few hundreds up to 6,000 feet in amount and produced the existing tablelands; the uplift, being a differential one, was accompanied in many places by warping and block-faulting. During this uplift certain areas lagged behind and remained practically stationary; examples of such "still-stand" areas are the Clarence River Basin and Lower Hawkesbury Basin of New South Wales, and that great belt of lowlands, sometimes referred to as the Great Valley of Victoria, which extends from east to west along the southern margin of the main belt of tablelands of that State. It is interesting to note that the extensive development of Pleistocene and perhaps Recent basaltic lavas and tuffs of Victoria are associated with the western part of this "still-stand" area.

Following the elevation of the tablelands a new cycle of erosion was initiated which is still in progress and which has brought about the dissection of the tablelands as we see them to-day.

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#### EXPLANATION OF PLATE A.

1.—View at Emmaville, showing typical "Upland Valley".

2.—View at Dalton, showing typical "Upland Valley" with leaf-bearing beds in foreground.

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Dr. G. A. Waterhouse, Honorary Treasurer, presented the balance-sheets for the year ended 28th February, 1937, duly signed by the Auditor, Mr. F. H. Rayment, F.C.A. (Aust.); and he moved that they be received and adopted, which was carried unanimously.

No nominations of other candidates having been received, the Chairman declared the following elections for the ensuing session to be duly made:

*President:* E. C. Andrews, B.A.

*Members of Council:* R. H. Anderson, B.Sc.Agr., Professor W. J. Dakin, D.Sc., H. S. Halero Wardlaw, D.Sc., G. A. Waterhouse, D.Sc., B.E., F.R.E.S., W. L. Waterhouse, M.C., D.Sc.Agr., D.I.C. (Lond.).

*Auditor:* F. H. Rayment, F.C.A. (Aust.).

A cordial vote of thanks to the retiring President was carried by acclamation.

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# Linnean Society of New South Wales.

GENERAL ACCOUNT. Balance Sheet at 28th February, 1937.

LIABILITIES.		£	s.	d.	£	s.	d.
Capital: Amount received from Sir William Macleay during his lifetime		14,000	0	0			
Further sum bequeathed by his Will		6,000	0	0			
Contingencies Reserve					20,000	0	0
Commercial Banking Co. of Sydney Ltd.					9,253	1	1
					655	18	3
					£29,913	19	4
ASSETS.		£	s.	d.	£	s.	d.
Society's Freehold							
Consols					11,000	0	0
Loans on Mortgage					3,600	0	0
Science House (one-third share)					14,590	0	0
Cash in hand					10	0	0
Income Account at 28th February, 1937					209	9	4
Bacteriology Account					4	10	9
					£29,913	19	4

## INCOME ACCOUNT. Year Ended 28th February, 1937.

£	s.	d.	£	s.	d.
To Balance from 1935-36			100	11	7
" Salaries			1,010	0	0
" Printing Publications			418	18	5
" Illustrations			71	19	8
Rates and Insurance			490	18	1
" Library			192	8	6
" Postage			7	2	8
" Petty Cash					
" Audit			55	6	3
" Printing			7	7	0
" Attendance and Cleaning			23	15	7
" Expenses			40	1	4
" Legal Expenses			22	17	11
" Auction Fee			2	2	0
Interest on Overdraft, etc.			10	0	0
" Bank Expenses			106	3	10
" Appropriation: Contingencies Reserve			8	3	6
			2	0	8
			29	8	0
			£2,002	3	1
By Subscriptions: 1936-37					
Arrears					
In Advance					
" Life Subscription			165	18	0
" Entrance Fees			15	15	0
" Interest			13	13	0
" Rent			258	8	0
" Science House			303	1	8
" Sales (including 60 copies of PROCEEDINGS purchased by Government of New South Wales)			185	0	0
" Fellowships Account (surplus income at 28th February, 1937, transferred)			150	3	8
" Library Refund			691	14	9
" Balance to 1937-38			8	19	8
			209	9	4

Examined and found correct. Securities produced.

F. H. RAYMENT, F.C.A. (Aust.),  
Auditor.

9th March, 1937.

3rd March, 1937.

G. A. WATERHOUSE,  
Hon. Treasurer.

£2,002 3 1

**LINNEAN MACLEAY FELLOWSHIPS ACCOUNT.**  
**BALANCE SHEET at 28th February, 1937.**

LIABILITIES.		ASSETS.	
	£ s. d.		£ s. d.
Amount bequeathed by Sir William Macleay ..	35,000 0 0	Consols ..	11,400 0 0
Surplus Income Capitalized ..	15,182 14 8	Loans on Mortgage ..	37,700 0 0
		Rural Loan ..	477 10 0
		Commercial Banking Company of Sydney Ltd. ..	501 14 1
		Commonwealth Savings Bank ..	103 10 7
	<u>£50,182 14 8</u>		<u>£50,182 14 8</u>

**INCOME ACCOUNT. Year Ended 28th February, 1937.**

	£ s. d.		£ s. d.
To Salaries of Linnean Macleay Fellows ..	1,266 13 4	By Interest ..	2,293 6 3
" Expenses ..	1 11 6		
" Capital Account ..	333 6 8		
" General Account ..	691 14 9		
	<u>£2,293 6 3</u>		<u>£2,293 6 3</u>

Examined and found correct. Securities produced.  
F. H. RAYMENT, F.C.A. (Aust.),  
Auditor.

9th March, 1937.

3rd March, 1937.

G. A. WATERHOUSE,  
Hon. Treasurer.

**BACTERIOLOGY ACCOUNT.**  
**BALANCE SHEET at 28th February, 1937.**

LIABILITIES.		ASSETS.	
	£ s. d.		£ s. d.
Amount bequeathed by Sir William Macleay ..	12,000 0 0	Consols ..	15,820 0 0
Accumulated Income Capitalized ..	3,820 0 0	Cash—	
Income Account at 28th February, 1937 ..	534 12 7	Commercial Banking Company of	
General Account ..	4 10 0	Sydney Ltd. ..	307 17 5
		Commonwealth Savings Bank ..	225 5 2
		In hand ..	6 0 0
	<u>£16,359 2 7</u>		<u>539 2 7</u>
			<u>£16,359 2 7</u>

**INCOME ACCOUNT. Year Ended 28th February, 1937.**

	£ s. d.		£ s. d.
To Salary ..	600 0 0	By Balance from 1935-36 ..	529 17 6
" Expenses ..	19 5 5	" Interest ..	624 14 3
" Petty Cash ..	0 13 9		
" Balance to 1937-38 ..	534 12 7		
	<u>£1,154 11 9</u>		<u>£1,154 11 9</u>

Examined and found correct. Securities produced.

F. H. RAYMENT, F.C.A. (Aust.),

Auditor.

9th March, 1937.

G. A. WATERHOUSE.

Hon. Treasurer.

3rd March, 1937.

## ABSTRACT OF PROCEEDINGS.

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### ORDINARY MONTHLY MEETING.

31st MARCH, 1937.

Mr. E. C. Andrews, B.A., President, in the Chair.

The Donations and Exchanges received since the previous Monthly Meeting (25th November, 1936), amounting to 49 Volumes, 554 Parts or Numbers, 17 Bulletins, 14 Reports and 42 Pamphlets, received from 177 Societies and Institutions and 4 private donors, were laid upon the table.

#### PAPERS READ.

1. Notes on the Genus *Calliphora* (Diptera). By G. H. Hardy.
2. The Structure of Galls formed by *Cyttaria septentrionalis* on *Fagus Moorei*. By Janet M. Wilson, B.A.
3. Entozoa from the Australian Hair Seal. By Professor T. Harvey Johnston, M.A., D.Sc., F.L.S.

### ORDINARY MONTHLY MEETING.

28th APRIL, 1937.

Mr. C. A. Sussmilch, Vice-President, in the Chair.

Dr. G. A. Currie, Canberra; Mr. Camille Deuquet, Wollongong; Miss Valerie M. B. May, Cremorne; Dr. B. L. Middleton, Murrurundi; and Mr. K. F. Plomley, Darlinghurst, were elected Ordinary Members of the Society.

The Chairman announced that the Council had elected Professor A. N. Burkitt, Professor W. J. Dakin, Dr. W. L. Waterhouse and Mr. C. A. Sussmilch to be Vice-Presidents for the Session 1937-38.

The Chairman announced that the Council had elected Dr. G. A. Waterhouse to be Honorary Treasurer for the Session 1937-38.

The Chairman also announced that the Council had elected Mr. Frank H. Taylor, F.R.E.S., F.Z.S., as a member of Council in place of the late Mr. W. W. Froggatt.

The Chairman offered the congratulations of members to Professor T. G. B. Osborn on his election to the Sherardian Professorship of Botany in the University of Oxford.

The Secretary called attention to the proposal to secure the preservation of Elizabeth Bay House, and it was unanimously resolved that members of the Linnean Society of New South Wales are of opinion that Elizabeth Bay House, on account of its historic and scientific associations, is worthy of preservation as a national monument, and express the hope that the movement with that object recently inaugurated in Sydney may be completely successful.

The Donations and Exchanges received since the previous Monthly Meeting (31st March, 1937), amounting to 14 Volumes, 63 Parts or Numbers, 1 Bulletin,

1 Report and 7 Pamphlets, received from 52 Societies and Institutions and 1 private donor, were laid upon the table.

## PAPERS READ.

1. The Distribution of Sooty-mould Fungi and its Relation to certain Aspects of their Physiology. By Lillian Fraser, M.Sc., Linnean Macleay Fellow of the Society in Botany.

2. Final Additions to the Flora of the Comboyne Plateau. By E. C. Chisholm, M.B., Ch.M.

3. On the Histological Structure of some Australian Galls. By Dr. E. Kuster. (Communicated by Dr. A. B. Walkom.)

4. A Census of the Orchids of New South Wales, 1937. By Rev. H. M. R. Rupp, B.A.

5. Australian Hesperilidae. vi. By G. A. Waterhouse, D.Sc., B.E., F.R.E.S.

6. Some Notes on the Nomenclature of certain Common Species of *Eucalyptus*. By Professor T. G. B. Osborn, D.Sc., F.L.S.

## NOTES AND EXHIBITS.

Mr. E. Cheel exhibited drawings illustrating variations in the venation of leaves of the following species of *Callistemon*: *C. salignus*, *C. paludosus*, *C. linearifolius*, and *C. acuminatus*. The normal venation of all species of the genus *Callistemon* shows a central prominent midrib and intramarginal nerves; and, on the same twig, two additional prominent nerves running parallel between the midrib and intramarginal nerves. Occasionally a leaf may be found with three additional nerves, two on one side and one on the other side of the midrib as shown in the illustration. Drawings were also exhibited showing the individual flowers solitary in the axils of the leaves and not formed into a spike as is usually seen in the normal forms of *Callistemon*.

Mr. T. H. Pincombe exhibited specimens of fossil insects from a newly-discovered outcrop in the Belmont district.

Miss A. Melvaine exhibited specimens of a species of *Stigmatomyces* which has been determined by Mrs. Lennox of Canberra, F.C.T., as *S. Sarcophagae* Thaxter. From an examination of the available literature, this species has been found to be a synonym of *S. limnophorae* Thaxter, and the latter name, being earlier in use, has precedence. The fungus belongs to the peculiar order Laboulbeniales, and was found by Dr. M. J. Mackerras on the fly *Calliphora augur* in some of the field traps of the Division of Economic Entomology of the Council for Scientific and Industrial Research, in Canberra. The plants of this species grow in considerable numbers in a compact group on the integument of the posterior part of the fly, attached only by a small basal foot which is embedded in the chitinous integument. Through this the fungus derives its food supplies. So far as can be ascertained, no species of *Stigmatomyces* have been previously recorded for Australia.

Miss L. Fraser exhibited co-type specimens of the following species of fungi collected by her in New South Wales and recently described as new by H. Sydow (Ann. Myc., xxxv, 1, 1937): *Puccinia orellana*, *Ustilago curta*, *U. serena*, *U. valentula*, *Sphacelotheca mutabilis*, *Sorosporium Fraserianum*, *S. polycarpum*, *Meliola Fraseriana*, *Dimerina Acronychiae*, *Leptosphaeria aliena*, *Phyllachora bella*, *Ph. Lyonsiae*, *Diatrypea palmicola*, *Schiffnerula Rubi*, *Asterina australiensis*, *A. decumana*, *A. Fraseriana*, *A. polyloba*, *A. puellaris*, *A. recta*, *Lembosia ardua*, *L. micrasca*, *Clypeolella Alphonitiae*, *C. Doryphorae*, *Belonopsis*

*eriophila*, *Dermatea Fraseriana*, *Tryblidaria australiensis*, *Apomella Casuarinae*. A number of other specimens which had been identified by Sydow were also exhibited.

Mrs. E. Coleman forwarded additional notes on the nest hygiene of birds as follows:

*Nest Hygiene of the British Song Thrush.*—Further observations make necessary some modification of my notes on nest hygiene of the British Song Thrush, published in The PROCEEDINGS, 1936, p. li. This season I have had three nests under even closer observation than those of last year. In each instance excreta were always removed directly from the cloaca of a nestling. In no instance, and I witnessed the removal over a hundred times, were excreta carried from the nest, but were swallowed by the adult bird as soon as taken. Often a parent bird fed two nestlings at a visit, disposing of both excrement-capsules in the same way. As both my camera and myself were fully screened, I think it must be assumed that this is the usual procedure, and that the actions of last season's birds were influenced by a knowledge of my proximity. Dead nestlings are always removed, but infertile eggs are allowed to remain in the nest.

*Nest Hygiene of the Blackbird.*—In the matter of nest hygiene, the habits of the Blackbird follow closely those of the British Song Thrush. Fully screened, and with my camera also hidden, although placed within eighteen inches of the nest, I have watched both feeding and nest hygiene. In two instances the male bird was not seen at the nest. Polygamy was suggested. I watched both nests for a month, and photographed the brood in many stages. In one of them there were four nestlings. Except excrement, I doubt if the hen-bird could have taken much food herself. Many times I saw her remove and swallow two, and even three, capsules at a visit.

#### ORDINARY MONTHLY MEETING.

26th May, 1937.

Mr. E. C. Andrews, B.A., F.R.S.N.Z., President, in the Chair.

Miss D. M. Cumpston, Newtown; Mr. J. A. Dulhunty, Glebe Point, and Miss E. A. Mercer, B.Sc.Agr., Lindfield, were elected Ordinary Members of the Society.

The President offered congratulations to Dr. Lillian Fraser on obtaining her Doctorate of Science of the University of Sydney.

The Donations and Exchanges received since the previous Monthly Meeting (28th April, 1937), amounting to 27 Volumes, 184 Parts or Numbers, 19 Bulletins, 5 Reports and 11 Pamphlets, received from 86 Societies and Institutions and 2 private donors, were laid upon the table.

#### PAPERS READ.

1. Two new Species and one new Variety of *Drimys* Forst., with Notes on the Species of *Drimys* and *Bubbia* Van Tiegh. of South-eastern Australia and Lord Howe Island. By Joyce W. Vickery, M.Sc.

2. Revision of Australian Lepidoptera. Oecophoridae. vi. By A. Jefferis Turner, M.D., F.R.E.S.

#### NOTES AND EXHIBITS.

Mr. E. Cheel exhibited live plants of *Oxalis acetosella* found naturalized in the Marrickville district, where it is regarded as a very bad weed-pest in gardens. Samples of *O. corniculata* (see These Proc., 1917, 512, and 1919, 525, for a note



on this species) were exhibited for comparison, as the foliage characters are very similar in general appearance. Mr. Cheel also exhibited live plants of *Pelargonium radulum* which has been found not to breed true when raised from seeds.

Mr. G. P. Whitley exhibited three post-larval specimens of a Snake Eel, *Malvoliophis pinguis* (Gunther, 1872). These were seined in 26 fathoms off Jervis Bay, New South Wales, and measured 41, 45, and 48 mm. They had passed the *Leptocephalus* stage and were practically metamorphosed, although no fins had developed. The myomeres numbered sixty-three, a very low number for an eel, and one specimen was conspicuously encircled by five brown bands. These eels were presented to the Australian Museum by Mr. Melbourne Ward, and an enlarged diagram of one specimen was also exhibited.

The Secretary read a letter from Dr. R. Broom, a Corresponding Member, giving some details of recent finds of fossil anthropoid remains in South Africa.

Mr. E. C. Andrews gave a short talk on his recent visit to Iceland and Norway.

### ORDINARY MONTHLY MEETING.

30th JUNE, 1937.

Mr. E. C. Andrews, B.A., F.R.S.N.Z., President, in the Chair.

The Donations and Exchanges received since the previous Monthly Meeting (26th May, 1937), amounting to 9 Volumes, 159 Parts or Numbers, 5 Bulletins, 2 Reports and 7 Pamphlets, received from 78 Societies and Institutions and 1 private donor, were laid upon the table.

#### PAPERS READ.

1. Australian Hesperilidae. vii. Notes on the Types and Type Localities. By G. A. Waterhouse, D.Sc., B.E., F.R.E.S.

2. Revision of the Genus *Fergusonina* Mall. (Diptera, Agromyzidae). By A. L. Tonnoir. (Communicated by Dr. G. A. Currie.)

#### NOTES AND EXHIBITS.

Mr. H. L. Jensen exhibited photographs of cultures of a blue-green alga (impure cultures, but free from nitrogen-fixing bacteria) capable of growth in an inorganic, nitrogen-free medium in which a small but definite fixation of atmospheric nitrogen takes place (1.2-1.4 mgm. N. per 50 c.c. medium in 8 weeks).

Miss A. Melvalne exhibited specimens of roots of *Exocarpus cupressiformis* Labill. parasitizing roots of *Casuarina suberosa* Ott. & Dietr. and also its own roots. The specimens were collected at Sussex Inlet, New South Wales, where the root systems were exposed by shifting sand. The roots of *Casuarina suberosa* showed the presence of coralloid rootlets which have previously been recorded only for *C. Cunninghamiana* Miq., *C. glauca* Sieb. and *C. torulosa* Ait.

Mr. E. Cheel exhibited a series of specimens of *Kunzea* as follows: *Kunzea opposita* F.v.M., from near Timbarra, New England district, and *Kunzea parvifolia* Schauer, from Braidwood district. Also *Kunzea* sp., probably *Kunzea calida* F.v.M., from Gilgandra, Torrington, Guyra, N.S.W., and from Stanthorpe and Wallangarra, Queensland. The latter (*K. calida*?) has not previously been recorded by Bentham, although originally described as distinct by Mueller in *Fragmenta*, vi, 1867, 23. Specimens were also exhibited from Copmanhurst, very closely resembling *Kunzea opposita* and erroneously determined as this species, but further investigations are being made with a view to revising the whole series

variously determined as *Melaleuca*, *Baeckea*, *Kunzea parvifolia*, *Kunzea peduncularis* and *Kunzea capitata*.

Dr. Lillian Fraser gave an account of the Ecology of Barrington Tops.

#### ORDINARY MONTHLY MEETING.

28th JULY, 1937.

Mr. E. C. Andrews, B.A., F.R.S.N.Z., President, in the Chair.

Mr. W. L. du Boulay, Elizabeth Bay, was elected an Ordinary Member of the Society.

The President announced that the operation of the Wild Flowers and Native Plants Protection Act, 1927, has been extended for a further period of one year from 1st July, 1937.

The Donations and Exchanges received since the previous Monthly Meeting (30th June, 1937), amounting to 20 Volumes, 143 Parts or Numbers, 5 Bulletins, 1 Report and 5 Pamphlets, received from 74 Societies and Institutions, were laid upon the table.

#### PAPERS READ.

1. Galls on Eucalyptus Trees. A new Type of Association between Flies and Nematodes. By G. A. Currie, D.Sc., B.Sc.Agr.
2. Notes on Fossil Diatoms from New South Wales. i. By B. V. Skvortzov. (*Communicated by Dr. A. B. Walkom.*)
3. The Growth of Soil on Slopes. By Professor J. Macdonald Holmes, Ph.D.

#### ORDINARY MONTHLY MEETING.

25th AUGUST, 1937.

Mr. E. C. Andrews, B.A., F.R.S.N.Z., President, in the Chair.

Mr. A. C. Simpson, Newtown, was elected an Ordinary Member of the Society.

The President announced that arrangements are being made by the David Portrait Committee for the unveiling of the portrait of the late Sir Edgeworth David in Science House to take place on Wednesday, 29th September, 1937, at 5 p.m.

The President referred to the death of the well-known naturalist, F. P. Dodd, of Kuranda, which took place on 27th July, 1937.

The Donations and Exchanges received since the previous Monthly Meeting (28th July, 1937), amounting to 16 Volumes, 170 Parts or Numbers, 13 Bulletins, 2 Reports and 14 Pamphlets, received from 75 Societies and Institutions and 1 private donor, were laid upon the table.

#### PAPERS READ.

1. A Monograph of the Australian Colydiidae. By H. J. Carter, B.A., F.R.E.S., and E. H. Zeck.
2. Notes on the Biology of *Tabanus froggatti*, *T. gentilis* and *T. neobasalis* (Diptera). By Mary E. Fuller, B.Sc.
3. The Occurrence of the Australian Pilchard (*Sardinops neopilchardus*) and its Spawning Season in New South Wales Waters, together with brief Notes on other New South Wales Clupeids. By Professor W. J. Dakin, D.Sc., C.M.Z.S.

## NOTES AND EXHIBITS.

Mr. E. Cheel exhibited fresh specimens of *Eucalyptus* taken from ten trees grown at Hill Top near Mittagong, and Ashfield, raised from seed collected at Braidwood, Nerrigundah, Wyndham, Batlow, Laurel Hill and Tumbarumba. In Bentham's *Flora Australiensis* and Moore and Betche's *Handbook of the Flora of New South Wales* the species from which the seeds were taken is classified as *E. amygdalina* Labill., and commonly known as "Black Peppermint", "Broad-leaf Peppermint" and "River White Gum" respectively. This classification was adopted by Mueller, Woolls, Deane, Maiden and others, but in more recent times the "Black Peppermint" and "River White Gum" have been regarded as sufficiently distinct from the Tasmanian plants described under the name *E. amygdalina* by Labillardière, the names *E. radiata* of Sieber and *E. numerosa* of Maiden having been taken up for the mainland forms. Bentham regarded *E. radiata* Sieber as a variety of *E. amygdalina* Labill., and included the "River White Gum" of Woolls from Bent's Basin under this variety. This has led to considerable confusion. In June, 1916, a series of specimens was collected from the above-mentioned localities by the exhibitor and handed to the late Mr. Maiden, with the result that it has been fairly clearly shown that the species *E. radiata* Sieber (DC. Prod., iii, p. 218, 1828, a specimen of which is represented in the National Herbarium of New South Wales), together with *E. numerosa* Maiden and *E. dives* Schauer, may be regarded as distinct from *E. amygdalina* of Labillardière originally collected in Tasmania. More recently the names *E. australiana*, *E. phellandra*, *E. Robertsoni* and *E. Lindleyana* var. *stenophylla* have been proposed as new species and new variety, but the resultant plants raised from seeds of these supposed new species show that they cannot be separated from *E. radiata* and *E. numerosa*. Photographic illustrations of fully matured seed-capsules of the different species were exhibited to support the evidence shown in the leaf characters.

Mr. Cheel also exhibited specimens, taken from plants in nature and in cultivation, of *Leptospermum pendulum* Sieber, listed as a synonym under *L. attenuatum* Sm., by Bentham and others. The two species are abundantly distinct. Specimens of an undescribed species of *Leptospermum* closely related to *L. flavescens* var. *grandiflorum* Benth. (which is probably *L. virgatum* Schauer and *L. Petersoni* Bailey) were also exhibited, together with several forms and varieties of *L. flavescens* Sm., for comparison.

Miss Joyce Allan exhibited, from the Australian Museum Collections, the following shells commensal-parasitic on Starfish, Sea-urchins, Mantis Shrimps, and Bêche-de-mer: Cap Limpet, *Thyca* sp., external on arm of starfish, *Linckia laevigata*, from the Mandated Territory of New Guinea.—Small univalves of the genus *Stylifer* living internally within the arms of the starfish *Ophidiaster granifer* from Masthead and North-West Islands, Great Barrier Reef. Two species living together, one of which encloses its shell in a fleshy mantle covering. A species of *Stylifer* from the inside of the arms of *Ophidiaster robillardii* from Masthead Island.—Two species of shells commensal externally on Sea-urchins. *Stylifer brunnea* on a Sea-urchin from Victoria, and *Scalenostoma striata* on *Phyllacanthus annulifera*, Port Curtis, Queensland.—A small bivalve, *Scintilla ephippodonta*, which lives in burrows of a South Australian mantis shrimp.—A species of *Eulima* which lives in the interior of bêche-de-mer (Holothuria), Queensland. Zoologists have found foreign bodies inside bêche-de-mer which they consider degenerated forms of these shells.—A small species, *Caledoniella montrouzieri*, living amongst the legs and swimmerets of a mantis shrimp,

*Gonodactylus chiragra*, Hook Reef, near Port Denison, Queensland. The finding of this commensal-parasitic shell in Australia was most fortunate, as it led to the re-classifying of a southern Australian deep-water shell, *Mysticoncha wilsoni* (Smith), which had previously and erroneously been placed in the genus *Caledoniella* by Basedow, 1905, and followed by Hedley, Thiele and other leading conchologists.

## ORDINARY MONTHLY MEETING.

29th SEPTEMBER, 1937.

Mr. E. C. Andrews, B.A., F.R.S.N.Z., President, in the Chair.

The President mentioned the death of Dr. F. G. Hardwick, who had been a member of the Society since 1922.

The President announced that the Council had elected Mr. A. R. Woodhill as a member of Council in place of Professor T. G. B. Osborn.

The President announced that the Council is prepared to receive applications for four Linnean Macleay Fellowships tenable for one year from 1st March, 1938, from qualified candidates. Applications should be lodged with the Secretary, who will afford all necessary information to intending candidates, not later than Wednesday, 3rd November, 1937.

The President drew attention to the fact that the Seventh International Congress for Entomology is to be held in Berlin from 15th to 20th August, 1938.

The Donations and Exchanges received since the previous Monthly Meeting (25th August, 1937), amounting to 12 Volumes, 127 Parts or Numbers, 16 Bulletins, 2 Reports and 3 Pamphlets, received from 63 Societies and Institutions and 1 private donor, were laid upon the table.

## PAPERS READ.

1. On the Identity of the Butterfly known in Australia as *Heteronympha philerope* Boisd., 1832. By G. A. Waterhouse, D.Sc., B.E., F.R.E.S.

2. The Petrology of the Hartley District. iv. The Altered Dolerite Dykes. By Germaine A. Joplin, B.Sc., Ph.D.

3. Notes on Australian Mosquitoes (Diptera, Culicidae). iii. The Genus *Aedomyia* Theobald. By I. M. Mackerras, M.B., Ch.M., B.Sc.

4. Notes on Australian Mosquitoes (Diptera, Culicidae). iv. The Genus *Theobaldia*, with Description of a New Species. By D. J. Lee, B.Sc.

## NOTES AND EXHIBITS.

Professor W. J. Dakin gave a short account of the occurrence of the Australian Pilchard and the life-history of the Australian Prawn.

The life-history of the Penaeidae has always aroused considerable scientific interest by reason of two facts: (1) The difference from the general type of development seen in the Decapoda—the expulsion of eggs which hatch as free-swimming nauplii; and (2) the singular difficulty which has been experienced all the world over in obtaining a complete series of larvae which could be definitely associated with an authenticated species of *Penaeus*.

A very complete study of *Penaeus plebejus* Hesse, off the coast of New South Wales and in the estuaries of the Clarence River, Port Stephens, Broken Bay, Port Jackson, Port Hacking and Lake Illawarra, has shown that, whilst its post-larval life and its growth to a moderate size take place in the river estuaries and coastal lakes of New South Wales, its reproduction takes place in the ocean.

The protozoal stages are not unlike those of the Brazilian species observed by Muller in 1863. A surprising feature of the life-history is the sequence of post-mysis stages during which the telson gradually changes in form until the adult characters are acquired. Larvae of all stages have been taken between May and August. The young King Prawns enter the estuaries during the pelagic stages. An account of the chief differences between the larval stages was given by Professor Dakin. The reproductive period in the sea extends at least from late summer up to September.

Mr. A. R. Woodhill exhibited specimens of larvae of the mosquitoes *Aedes* (*Pseudosclusca*) *concolor*, *Culex fatigans*, *Aedes* (*Ochlerotatus*) *vigilar*, and *Megarrhinus speciosus* and gave a short account of the habitat and salinity tolerances of the various species of larvae.

Mr. A. N. Colefax sent for exhibition the results of two quarter-hour catches taken at Lake Illawarra. They were taken with a very coarse net and an ordinary coarse net. One haul revealed the presence of an enormous number of a new genus of mysid crustacean, while the other contained a large quantity of a copepod, also a new genus. The hauls both reveal the high productivity of the lake.

Mr. E. Cheel exhibited specimens of a species of lichen, *Parmeliopsis semi-viridis* (F.v.M.) Nyl., collected at Curlew in February, 1933, by himself, and at Copeton, near Inverell, by Mr. A. E. Watson recently. Previous records for this interesting lichen, which rolls from place to place on the surface of the soil, are given in the PROCEEDINGS of this Society (1909, p. 501; and 1913, p. 396), and a note on its peculiar habit in the *Australian Naturalist* (Vol. 3, 1916, p. 1922).

Mr. A. H. Volsey exhibited specimens of *Linoproductus springsurensis* Booker and other brachiopods from Kimbriki, 12 miles from Wingham, where they occur on a horizon low down in the Kamilaroi rocks; also fossil plants (*Thinnfeldia* and *Gladophlebis*) of Triassic age from near Laurieton, Camden Haven district.

#### ORDINARY MONTHLY MEETING.

27th OCTOBER, 1937.

Mr. E. C. Andrews, B.A., F.R.S.N.Z., President, in the Chair.

The President reminded candidates for Linnean Macleay Fellowships, 1938-39, that Wednesday, 3rd November, 1937, is the last day for receiving applications.

The President informed members that the Council had decided that when the author of a paper so desires the date of receipt of his manuscript by the Society shall be printed at the head of the paper and that in such cases no material alteration of the paper shall be allowed after the date indicated.

The Donations and Exchanges received since the previous Monthly Meeting (29th September, 1937), amounting to 19 Volumes, 209 Parts or Numbers, 9 Bulletins, 2 Reports and 8 Pamphlets, received from 86 Societies and Institutions and 1 private donor, were laid upon the table.

#### PAPERS READ.

1. Notes on Australian Orchids. III. A Review of the Genus *Cymbidium* in Australia. II. By Rev. H. M. R. Rupp, B.A.

2. The Ecology of the Upper Williams River and Barrington Tops Districts. I. Introduction. By Lillian Fraser, D.Sc., and Joyce W. Vickery, M.Sc.

3. Notes on some Species occurring in the Upper Williams River and Barrington Tops Districts, with Descriptions of New Species and Varieties. By Lillian Fraser, D.Sc., and Joyce W. Vickery, M.Sc.

4. The Occurrence of Graptolites near Yass, N.S.W. By Kathleen Sherrard, M.Sc., and R. A. Keble, F.G.S.

## NOTES AND EXHIBITS.

Mr. D. Gilmour and Mr. M. Griffiths exhibited photographs and specimens illustrating a survey of the animal ecology of a freshwater pond which is being carried out at Narrabeen. A permanent pond of this type, with a complete covering of aquatic vegetation, is rather unusual in Australia. An account was given of the methods used in the investigation and attention was drawn to a food-chain illustrating the interrelations of the individuals of the animal community.

Mr. Consett Davis exhibited a series of aerial photographs of the Five Islands.

Rev. H. M. R. Rupp exhibited a flowering specimen of a new Australian *Dendrobium* (*D. Fleckeri* White and Rupp) from the neighbourhood of Cairns.

Mrs. C. A. Messmer exhibited a flowering specimen of *Boronia* (? *B. anemonifolia*) from Mittagong.

## ORDINARY MONTHLY MEETING.

24th NOVEMBER, 1937.

Mr. E. C. Andrews, B.A., F.R.S.N.Z., President, in the Chair.

Mr. L. R. Clark, Cremorne; Dr. Edward Ford, Sydney University; Mr. G. L. Kesteven, Strathfield; and Mr. R. D. Wilson, Department of Agriculture, Sydney, were elected Ordinary Members of the Society.

The President announced that the Council had reappointed Miss Elizabeth C. Pope, B.Sc., Mr. H. F. Consett Davis, B.Sc., Mr. A. H. Voisey, M.Sc., and Miss Ilma M. Pidgeon, M.Sc., to Linnean Macleay Fellowships in Zoology, Zoology, Geology and Botany respectively, for one year from 1st March, 1938.

The Donations and Exchanges received since the previous Monthly Meeting (27th October, 1937), amounting to 3 Volumes, 74 Parts or Numbers, 1 Bulletin, 4 Reports and 1 Pamphlet, received from 56 Societies and Institutions, were laid upon the table.

## PAPERS READ.

1. The Carboniferous Sequence in the Werrie Basin (With Palaeontological Notes by Ida A. Brown, D.Sc.). By S. W. Carey, M.Sc.

2. The Ecology of the Central Coastal Area of New South Wales. i. The Environment and General Features of the Vegetation. By Ilma M. Pidgeon, M.Sc., Linnean Macleay Fellow of the Society in Botany.

3. A Note on the Ascigerous State of *Claviceps Paspali* S. & H. in Australia. By W. L. Waterhouse, D.Sc.Agr.

## NOTES AND EXHIBITS.

Mr. E. Cheel exhibited specimens of juvenile and adult foliage taken from an original plant raised from seed received from Botanic Gardens, Berlin, in 1913, under the name *Callistemon amoenus*, together with foliage and colour notes of flowers raised from seeds of the Berlin plants. The flowers of *C. amoenus* are creamy white (vide Lemaire's *Illust. Horticole*). The flowers of the plants raised from the Berlin seeds are reddish-purple to purple-garnet. The flowering spikes of the plants raised from the original plant are almost identical, but the foliage characters of the Australian raised seedlings are very variable, the leaves being much larger and coarser than those of the parent plant.

## DONATIONS AND EXCHANGES.

Received during the period 29th October, 1936, to 27th October, 1937.

(From the respective Societies, etc., unless otherwise mentioned.)

- ABERYSTWYTH.**—*Welsh Plant Breeding Station, University College of Wales.* "The Welsh Journal of Agriculture", xiii (1937); Survey of the Work of the Agricultural Departments of the University College of Wales (1936).
- ACCRA.**—*Geological Survey Department, Gold Coast Colony.* Report for the Financial Year 1935-36 (1936).
- ADLAIDE.**—*Department of Mines: Geological Survey of South Australia.* Annual Report of the Director of Mines and Government Geologist for 1935 (1936); Bulletin No. 16 (1937); Mining Review for the Half-years ended 30th June, 1936 (No. 64) (1936) and 31st December, 1936 (No. 65) (1937).—*Field Naturalists' Section of the Royal Society of South Australia and South Australian Aquarium Society.* "South Australian Naturalist", xvi, 4 (1937); xvii, 1-4 (being "National Park, South Australia") (1936).—*Public Library, Museum and Art Gallery of South Australia.* 52nd Annual Report of the Board of Governors, 1935-36 (1936); Records of the South Australian Museum, v, 4 (T.p. & c.) (1936).—*Royal Society of South Australia.* Transactions and Proceedings, lx (1936).—*South Australian Ornithological Association.* "The South Australian Ornithologist", xlii, 8 (1936); xiv, 1-3 (1937).—*University of Adelaide.* "The Australian Journal of Experimental Biology and Medical Science", xiv, 3-4 (T.p. & c.) (1936); xv, 1-3 and Supplement (1937).—*Woods and Forests Department.* Annual Report for the Year ended 30th June, 1936 (1936).
- ALBANY.**—*New York State Library, University of the State of New York.* New York State Museum Bulletin, Nos. 305, 307-309 (1936-1937); New York State Museum Handbook 11, 16 (1935, 1936).
- ALGER.**—*Institut Pasteur d'Algérie.* Archives, xiv, 4 (Contents) (1936); xv, 1-2 (1937).—*Société d'Histoire Naturelle de l'Afrique du Nord.* Bulletin, xxvii, 6-9 (T.p. & c.) (1936); xxviii, 1-3 (1937).
- AMSTERDAM.**—*Koninklijke Akademie van Wetenschappen.* Proceedings of the Section of Sciences, xxxviii, 6-10 (T.p. & c. and Index) (1935); xxxix, 1-10 (T.p. & c.) (1936); Verhandelingen Afdeling Natuurkunde, 2<sup>e</sup> Sectie, xxxiv, 1-6 (T.p. & c.) (1934-1935); xxxv, 1-4 (T.p. & c.) (1936).—*Nederlandsche Entomologische Vereniging.* Entomologische Berichten, lx, 210-215 (1936-1937); Tijdschrift voor Entomologie, lxxix, 3-4 (T.p. & c.) (1936); lxxx, 1-2 (1937).
- ANN ARBOR.**—*University of Michigan.* Contributions from the Laboratory of Vertebrate Genetics, Nos. 1-5 (1936-1937); Contributions from the Museum of Palaeontology, T.p. & c. for Vol. iv (1935); v, 1-6 (1936); Miscellaneous Publications of the Museum of Zoology, Nos. 31-34 (1936-1937); Occasional Papers of the Museum of Zoology, Nos. 325-348 (1936-1937); Papers of the Michigan Academy of Science, Arts and Letters, xxi, 1935 (1936).
- ATHENS.**—*Zoological Institute and Museum, University of Athens.* Acta, i, 6-10 (1936-1937).
- AUCKLAND.**—*Auckland Institute and Museum.* Records, ii, 1 (1936).
- BALTIMORE.**—*Johns Hopkins University.* Bulletin of the Johns Hopkins Hospital, lix, 2-6 (T.p. & c.) (1936); lx, 1-6 (T.p. & c.) (1937); lxi, 1-3 (1937).

- BANDOENG.**—*Dienst van den Mijnbouw in Nederlandsch-Indië*. Bulletin of the Netherlands Indies Volcanological Survey, Nos. 76-79 (1936-1937).
- BARCELONA.**—*Academia de Ciencias i Arts*. Butlletí, Tercera Epoca, vi, 7 (1936); *Memories*, Tercera Epoca, xxv, 11-16 (1936); *Nomina del Personal Academic*, 1935-36 (1936).
- BASEL.**—*Naturforschende Gesellschaft*. Verhandlungen, xlvii, 1935-36 (1936).—*Schweizerische Naturforschende Gesellschaft*. Verhandlungen, 117. Jahresversammlung, 1936 (1936).
- BATAVIA.**—*Departement van Economische Zaken*. Bulletin du Jardin Botanique, Serie III, xlii, 4 (T.p. & c.) (1936); xiv, 1-2 (1936-1937); xv, 1 (1936); "Treubia", xv, 4 (T.p. & c.) (1936); xvi, 1 (1937).—*Koninklijke Natuurkundige Vereeniging in Nederlandsch-Indië*. Natuurkundig Tijdschrift voor Nederlandsch-Indië, xcvi, 4 (T.p. & c.) (1936); xcvi, 1-7 (1936-1937).—*Natuurwetenschappelijke Raad voor Nederlandsch-Indië te Batavia (Netherlands India Science Council)*. Publication, Nos. 10 (Maart, 1937); 12 (Augustus, 1937).
- BERGEN.**—*Bergens Museum*. Arbok, 1936, 2 (T.p. & c.) (1937); *Arsheretning*, 1935-36 (1936).
- BERKELEY.**—*University of California*. Bulletin of the Department of Geological Sciences, xxiv, 1-7 (1936-1937); Publications, Botany, xix, 5 (1936); Entomology, vi, 13 (1937); Physiology, viii, 9-11 (1936); Public Health, ii, 2 (1936); Zoology, xii, 8-16 (1936-1937); Publications of the University of California at Los Angeles in Biological Sciences, i, 7-8 (1937).
- BERLIN.**—*Deutsch-Ausländischer Buchtausch*. "Flora", Neue Folge, xxx, 4 (T.p. & c.) (1936); xxxi, 1-4 (T.p. & c.) (1936-1937); xxxii, 1 (1937).—*Deutsche Entomologische Gesellschaft, E.V.* Deutsche Entomologische Zeitschrift, 1935, 3-4 (T.p. & c.) (1936); 1936, 1-4 (1936-1937); Mitteilungen, vii, 1-10 (T.p. & c.) (1936-1937); viii, 1 (1937).—*Zoologische Museum*. Mitteilungen, xxi, 2 (T.p. & c.) (1936); xxii, 1 (1937).
- BERLIN-DAHLEM.**—*Botanisch Garten und Museum*. Notizblatt, xlii, 118-119 (1936-1937).—*Deutsches Entomologisches Institut*.—Arbeiten über morphologische und taxonomische Entomologie aus Berlin-Dahlem, iii, 3-4 (T.p. & c.) (1936); iv, 1-2 (1937); Arbeiten über physiologische und angewandte Entomologie aus Berlin-Dahlem, iii, 3-4 (T.p. & c.) (1936); iv, 1-2 (1937); Entomologische Beihefte aus Berlin-Dahlem, iii-iv (1936-1937).
- BERN.**—*Naturforschende Gesellschaft*. Mitteilungen a.d. Jahre 1936, 1-2 (T.p. & c.) (1936-1937).
- BLOEMFONTEIN.**—*Nasionale Museum*. Soologiese Navorsing, i, 3-6 (1936-1937).
- BOLOGNA.**—*Istituto di Entomologia della R. Università di Bologna (formerly Laboratorio di Entomologia del R. Istituto Superiore Agrario di Bologna)*. Bollettino, vii (1934-1935); viii (1935-1936).
- BOMBAY.**—*Bombay Natural History Society*. Journal, T.p. & c. for xxxviii, Nos. 3-4 (1937); xxxix, 1-2 (T.p. & c.) (1936-1937); xxxix, 3 (1937).
- BONN.**—*Naturhistorischer Verein der Rheinlande und Westfalens*. "Decheniana", xciii-xciv (1936-1937).
- BOSTON.**—*American Academy of Arts and Sciences*. Proceedings, lxxi, 3-10 (T.p. & c.) (1936-1937).—*Boston Society of Natural History*. Proceedings, xii, 5 (1937); New England Museum of Natural History, Annual Report, 1936-1937 (1937).
- BRISBANE.**—*Department of Agriculture*. Queensland Agricultural Journal, xli, 5-6 (T.p. & c.) (1936); xlvii, 1-6 (T.p. & c.); xlviii, 1-4 (1937).—*Department of Mines: Geological Survey of Queensland*. "Queensland Government Mining Journal", xxxvii, Oct.-Dec., 1936 (T.p. & c.) (1936); xxxviii, Jan.-Sept., 1937 (1937).—*Queensland Museum*. Memoirs, xi, 2 (1937).—*Queensland Naturalists' Club and Nature-Lovers' League*. "The Queensland Naturalist", x, 2-3 (1937).



- BRNO.—*Prirodovedecká Fakulta, Masarykovy University*. "Reliquiae Formanekianae" by C. Vandas (1939).
- BROOKLYN.—*Brooklyn Botanic Garden*. "Genetics", xxi, 6 (T.p. & c.) (1936); xxii, 1-5 (1937).
- BRUSSELS.—*Académie Royale des Sciences, des Lettres et des Beaux-Arts de Belgique*, 103<sup>me</sup> Annuaire, 1937 (1937); Bulletin de la Classe des Sciences, 5<sup>me</sup> Série, xxii, 6-12 (T.p. & c.) (1936); xxiii, 1-5 (1937).—*Musée Royal d'Histoire Naturelle de Belgique*. Bulletin, xii, 1-33 (1936); Mémoires, Nos. 74-78 (1936); Mémoires, 2<sup>me</sup> Série, Fasc. 4-7 (1936); Mémoires, Hors Série (Résultats Scientifiques du Voyage aux Indes Orientales Néerlandaises), T.p. & c. for Vol. iv (1935).—*Société Entomologique de Belgique*. Bulletin and Annales, lxxvi, 6-12 (T.p. & c.) (1936); lxxvii, 1-5 (1937).—*Société Royale de Botanique de Belgique*. Bulletin, lxxvii, 2 (T.p. & c.) (1936); lxxix, 1-2 (T.p. & c.) (1936-1937).—*Société Royale Zoologique de Belgique*. Annales, lxxvi, 1935 (1936).
- BUDAPEST.—*Hungarian National Museum; Zoological Department*. Annales Historico-Naturales, xxx (1936).
- BUENOS AIRES.—*Ministerio de Agricultura de la Nación*. Memoria de la Comisión Central de Investigaciones sobre la Langosta. Correspondiente al Año 1934 (1936).—*Museo Argentino de Ciencias Naturales*. Anales, xxxviii (1934-1936).—*Sociedad Argentina de Ciencias Naturales*. Revista "Physis", xli, 43 (1936).—*Sociedad Entomologica Argentina*. Revista, viii (complete) (1936).
- BUITENZORG.—*Nederlandsch-Indische Entomologische Vereeniging*. Entomologische Mededeelingen van Nederlandsch-Indië, T.p. & c. for I-II (1935-1936); II, 4 (1936); III, 1-3 (1937).
- CAIRNS.—*North Queensland Naturalists' Club*. "North Queensland Naturalist", v, 49 and Supplement, 50 and Supplement, 51 and Supplement (1937).
- CALCUTTA.—*Geological Survey of India*. Memoirs, lxxix, 1 (1937); lxx, pt. 2, No. 1 (1936); lxxi (1937); Memoirs, Palaeontologia Indica, N.S. xx, 6 (T.p. & c.) (1937); xxii, 6 (1936); xxiii, 1 (1936); xxiv, 1 (1937); Records, lxxi, 2-3 (1936); lxxii, 1 (1937).—*Zoological Survey of India*. Memoirs of the Indian Museum, xi, 4 (T.p. & c.) (1936-1937); Records of the Indian Museum, xxxviii, 2-4 (T.p. & c.) (1936-1937); xxxix, 1-2 (1937).
- CAMBRIDGE.—*Cambridge Philosophical Society*. Biological Reviews, xi, 4 (T.p. & c.) (1936); xli, 1-3 (1937).—*University of Cambridge*. Abstracts of Dissertations approved for the Ph.D., M.Sc., and M.Litt. Degrees during the Academical Year 1935-36 (1936).
- CAMBRIDGE, MASS.—*Museum of Comparative Zoology at Harvard College*. Annual Report of the Director for 1935-36 (1936); Bulletin, lxxix, 5-7 (1936); lxxx, 2-8 (1936-1937); lxxxii, 1-3 (T.p. & c.) (1937); lxxxii, 1 (1937).
- CANBERRA.—*Commonwealth Bureau of Census and Statistics*. Official Year Book, No. 29, 1936 (1936).—*Council for Scientific and Industrial Research; Divisions of Economic Entomology and Plant Industry*. Contributions (Economic Entomology), Nos. 103-109; (Plant Industry), Nos. 50-76 (1936-37).
- CAPE TOWN.—*Royal Society of South Africa*. Transactions, xxiv, 2-4 (T.p. & c.) (1936-1937).—*South African Museum*. Annals, xxiv, 4 (1936); xxxi, 3 (1936); xxxii, 2 (1937); Report for Year ended 31st December, 1936 (1937).
- CHICAGO.—*Field Museum of Natural History*. Botany. Leaflet 18-20 (1936-1937); Publications, Botanical Series, ix, 3 (1937); xi, 6 (T.p. & c.) (1936); xlii, pt. 1, No. 3; pt. 2, No. 1; pt. 2, No. 2; pt. 6; xv; xvii, 1 (1936-1937); Geological Series, vi, 15-17; vii, 1-2 (1936-1937); Report Series, xi, 1 (1937); Zoological Series, xlii, 9-10 (1936-1937); xx, 13-22 (1936); xxii, 1-2 (1936).—*John Crerar Library*. 38th Report for the Years 1932-1936 (1937).
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## LIST OF MEMBERS, 1937.

## ORDINARY MEMBERS.

- 1927 \*Albert, Michel François, "Boomerang", Elizabeth Bay, Sydney.  
 1929 Allan, Miss Catherine Mabel Joyce, Australian Museum, College Street, Sydney.  
 1905 Allen, Edmund, c/o Mulgrave Mill, Gordonvale, Queensland.  
 1906 Anderson, Charles, M.A., D.Sc., Australian Museum, College Street, Sydney.  
 1922 Anderson, Robert Henry, B.Sc.Agr., Botanic Gardens, Sydney.  
 1899 Andrews, Ernest Clayton, B.A., F.R.S.N.Z., No. 4, "Kuring-gal", 241 Old South Head Road, Bondi.  
 1932 Andrews, John, B.A., Ph.D., Department of Geography, Sydney University.  
 1927 Armstrong, Jack Walter Trench, "Callubri", Nyngan, N.S.W.  
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 1913 Badham, Charles, M.B., Ch.M., B.Sc., Bureau of Microbiology, 93 Macquarie Street, Sydney.  
 1888 Baker, Richard Thomas, The Crescent, Cheltenham.  
 1919 Barnett, Marcus Stanley, 44 Fox Valley Road, Wahroonga.  
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 1907 Benson, Professor William Noel, B.A., D.Sc., F.G.S., University of Otago, Dunedin, N.Z.  
 1920 Blakely, William Faris, Botanic Gardens, Sydney.  
 1929 Boardman, William, Australian Museum, College Street, Sydney.  
 1935 Bourne, Geoffrey, D.Sc., School of Public Health and Tropical Medicine, Sydney University.  
 1923 Brough, Patrick, M.A., D.Sc., B.Sc.Agr., Botany School, Sydney University.  
 1921 Brown, Horace William, 871 Hay Street, Perth, W.A.  
 1924 Brown, Miss Ida Alison, D.Sc., "Caversham", 166 Brook Street, Coogee.  
 1911 Browne, William Rowan, D.Sc., Geology Department, The University, Sydney.  
 1932 Bryce, Ernest John, 47 Nelson Road, Killara.  
 1931 Burges, Norman Alan, M.Sc., Ph.D., 35 Wetherell Street, Croydon.  
 1920 Burkitt, Professor Arthur Neville St. George Handcock, M.B., B.Sc., Medical School, The University, Sydney.  
  
 1901 Campbell, John Honeyford, I.S.O., M.B.E., Royal Canadian Mint, Ottawa, Canada.  
 1927 Campbell, Thomas Graham, Flat No. 4, 806 Military Road, Mosman.  
 1930 Carey, Miss Gladys, M.Sc., 32 Rawson Street, Epping.  
 1934 Carey, Samuel Warren, M.Sc., c/o Oil Search Ltd., 359 George Street, Sydney.  
 1905 Carne, Walter Mervyn, University of Tasmania, Hobart, Tasmania.  
 1908 Carter, Herbert James, B.A., F.R.E.S., "Garrawillah", Kintore Street, Wahroonga.  
 1936 \*Chadwick, Clarence Earl, B.Sc., Hurlstone Agricultural High School, Glenfield, N.S.W.  
 1899 Cheel, Edwin, 40 Queen Street, Ashfield.  
 1924 Chisholm, Edwin Claud, M.B., Ch.M., Barellan, N.S.W.  
 1932 Churchward, John Gordon, B.Sc.Agr., Ph.D., Faculty of Agriculture, Sydney University.  
 1901 Cleland, Professor John Burton, M.D., Ch.M., The University, Adelaide, S.A.  
 1931 Colefax, Allen N., B.Sc., Department of Zoology, Sydney University.  
 1933 Coleman, Mrs. Edith, "Walsham", Blackburn Road, Blackburn, Victoria.  
 1908 Cotton, Professor Leo Arthur, M.A., D.Sc., Geology Department, The University, Sydney.  
 1928 Craft, Frank Alfred, B.Sc., 8, "Wyalong", Melody Street and Allison Road, Coogee.  
 1937 Cumpston, Miss Dora Margaret, The Women's College, Newtown.  
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- 1934 Davidson, Harold James, 14 Princess Avenue, North Strathfield.
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- 1925 de Beuzeville, Wilfred Alexander Watt, J.P., "Melamere," Welham Street, Beecroft.
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- 1921 Dodd, Alan Parkhurst, Prickly Pear Laboratory, Sherwood, Brisbane, Q.
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- 1937 Dulhunty, John Allan, 250 Glebe Road, Glebe Point.
- 1926 Dumigan, Edward Jarrett, State School, Toowoomba East, Queensland.
- 1920 Dwyer, Rt. Rev. Joseph Wilfrid, Bishop of Wagga, Wagga Wagga, N.S.W.
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- 1930 English, Miss Kathleen Mary Isabel, B.Sc., March Street, Yass, N.S.W.
- 1914 Enright, Walter John, B.A., West Maitland, N.S.W.
- 1930 Fraser, Miss Lillian Ross, D.Sc., "Hopetoun", Bellamy Street, Pennant Hills.
- 1911 Froggatt, John Lewis, B.Sc., Department of Agriculture, Rabaul, New Guinea.
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- 1936 Gilmour, Darcy, B.Sc., 325 Livingstone Road, Marrickville.
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- 1912 Goldfinch, Gilbert Macarthur, University Club, 70 Phillip Street, Sydney.
- 1911 Greenwood, William Frederick Neville, F.L.S., F.R.E.S., c/o Colonial Sugar Refining Co., Ltd., Lautoka, Fiji.
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 1921 Osborne, George Davenport, D.Sc., Geology Department, The University, Sydney.

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- 1924 Roberts, Frederick Hugh Sherston, M.Sc., Department of Agriculture and Stock, Animal Health Station, Yeerongpilly, Brisbane, Q.
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- 1930 Sherrard, Mrs. Kathleen Margaret, M.Sc., 43 Robertson Road, Centennial Park, Sydney.
- 1937 Simpson, Arthur Cecil, St. Paul's College, Newtown.
- 1909 Smith, George Percy Darnell, D.Sc., F.I.C., F.C.S., c/o Lyon's Boat Shed, The Spit, Mosman, Sydney.
- 1928 Smith, Jacob Harold, M.Sc., N.D.A., Department of Agriculture and Stock, Nambour, Queensland.
- 1928 Smith, Thomas Hodge, Australian Museum, College Street, Sydney.
- 1916 Smith, Miss Vera Irwin, B.Sc., F.L.S., "Loana", Mt. Morris Street, Woolwich.
- 1935 Spence, Kenneth Kinross, M.B., Ch.M., 51 Sophia Street, Bondi Beach.
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- 1905 Stokes, Edward Sutherland, M.B., Ch.M., 15 Highfield Road, Lindfield.
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- 1930 Taylor, Frank Henry, F.R.E.S., F.Z.S., School of Public Health and Tropical Medicine, Sydney University.
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- 1902 Turner, A. Jeffers, M.D., F.R.E.S., Dauphin Terrace, Brisbane, Queensland.
- 1904 Turner, Rowland E., F.Z.S., F.R.E.S., c/o Standard Bank of South Africa, Adderley Street, Cape Town, South Africa.
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- 1930 Vickery, Miss Joyce Winifred, M.Sc., 6 Coventry Road, Homebush.
- 1934 Volsey, Alan Heywood, M.Sc., St. George's Hostel, West Kempsey, N.S.W.
- 1900 Walker, Commander John James, M.A., F.L.S., F.R.E.S., R.N., "Aorangi", Lonadale Road, Summertown, Oxford, England.
- 1899 Walkom, Arthur Bache, D.Sc., Science House, Gloucester and Essex Streets, Sydney.
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- 1911 Wardlaw, Henry Sloane Halcro, D.Sc., Physiology Department, The University, Sydney.

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 1928 Waterhouse, Lionel Lawry, B.E., "Rarotonga", 42 Archer Street, Chatswood.  
 1927 Waterhouse, Walter Lawry, D.Sc.Agr., M.C., D.I.C. (Lond.), Faculty of Agriculture, Sydney University.  
 1911 Watt, Professor Robert Dickie, M.A., B.Sc., University of Sydney.  
 1936 White, Neville H., c/o Council for Scientific and Industrial Research, University of Tasmania, Hobart, Tasmania.  
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 1934 Wilson, Miss Janet Marlon, B.A., 8 Lloyd Avenue, Hunter's Hill.  
 1934 Womersley, Herbert, F.R.E.S., A.L.S., South Australian Museum, Adelaide, South Australia.  
 1932 Woodhill, Anthony Reeve, B.Sc.Agr., Department of Zoology, Sydney University.  
 1925 Wright, Fred, 35 Bligh Street, Sydney.  
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HONORARY MEMBERS.

- 1923 Hill, Professor J. P., Institute of Anatomy, University of London, University College, Gower Street, London, W.C.1, England.  
 1923 Wilson, Professor J. T., LL.D., M.B., Ch.M., F.R.S., Department of Anatomy, the New Museums, Cambridge, England.

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- 1888 Bale, W. M., F.R.M.S., 63 Walpole Street, Kew, Melbourne, Victoria.  
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 1902 Meyrick, Edward, B.A., F.R.S., F.Z.S., Thornhanger, Marlborough, Wilts., England.

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- 1934 Waterhouse, John Talbot, 39 Stanhope Road, Killara.

\* Life Member.

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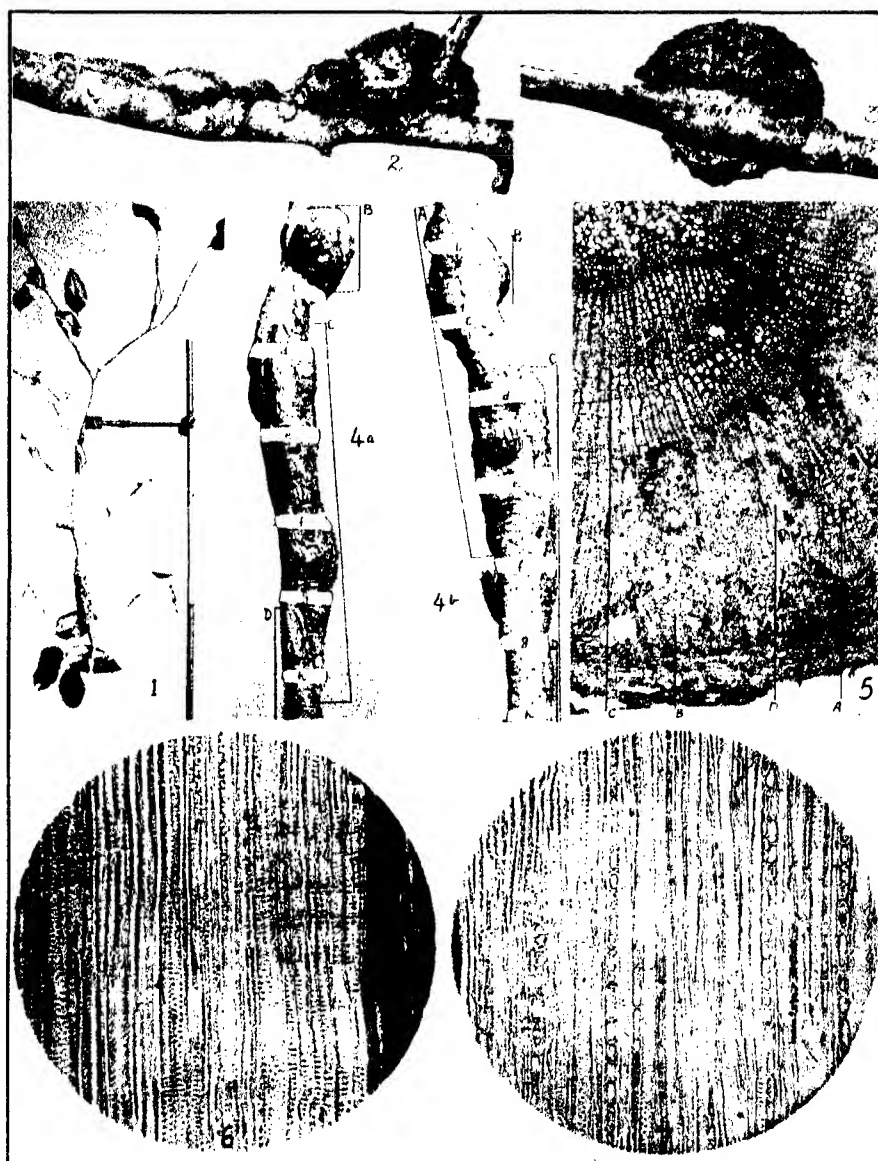
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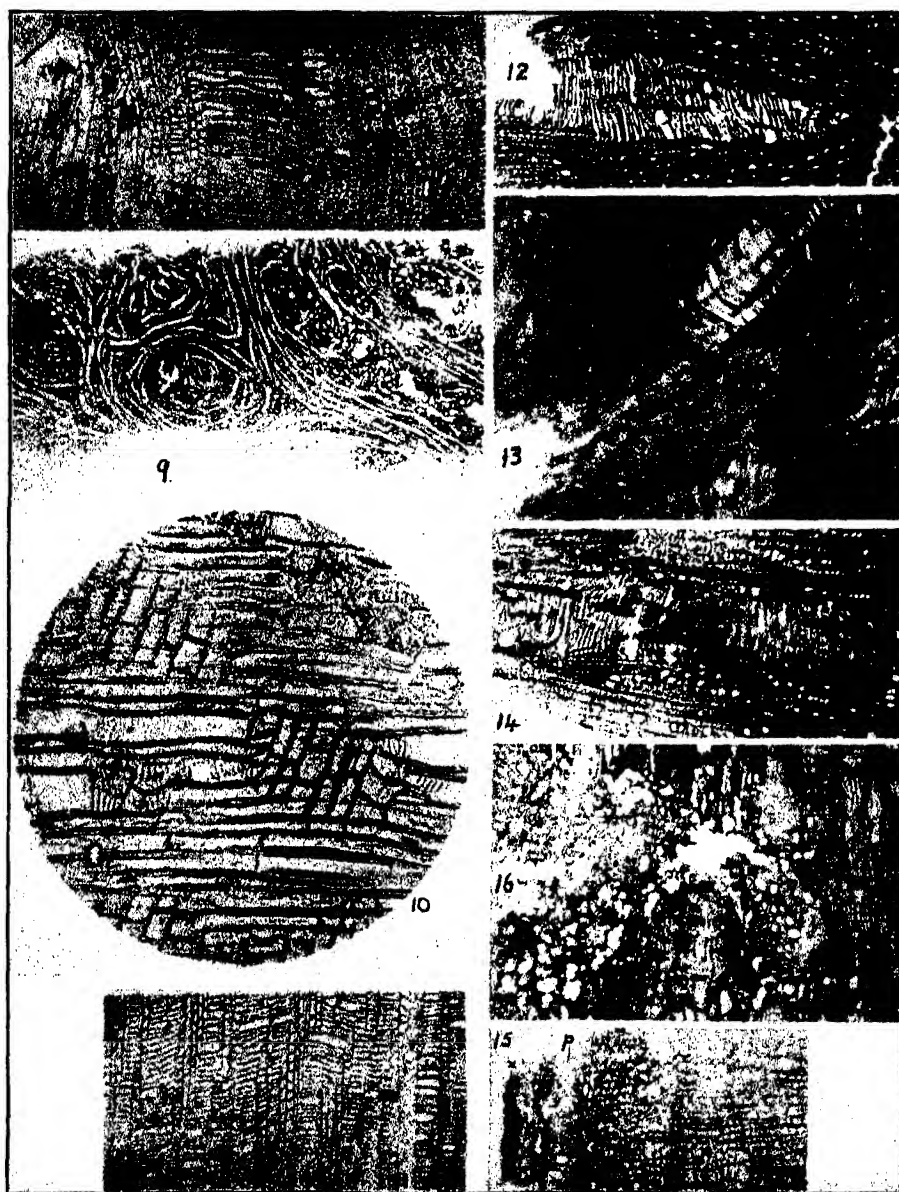
Views at Emmaville (1) and Dalton (2) showing typical "upland valleys".





Galls on *Fagus Moorri*.

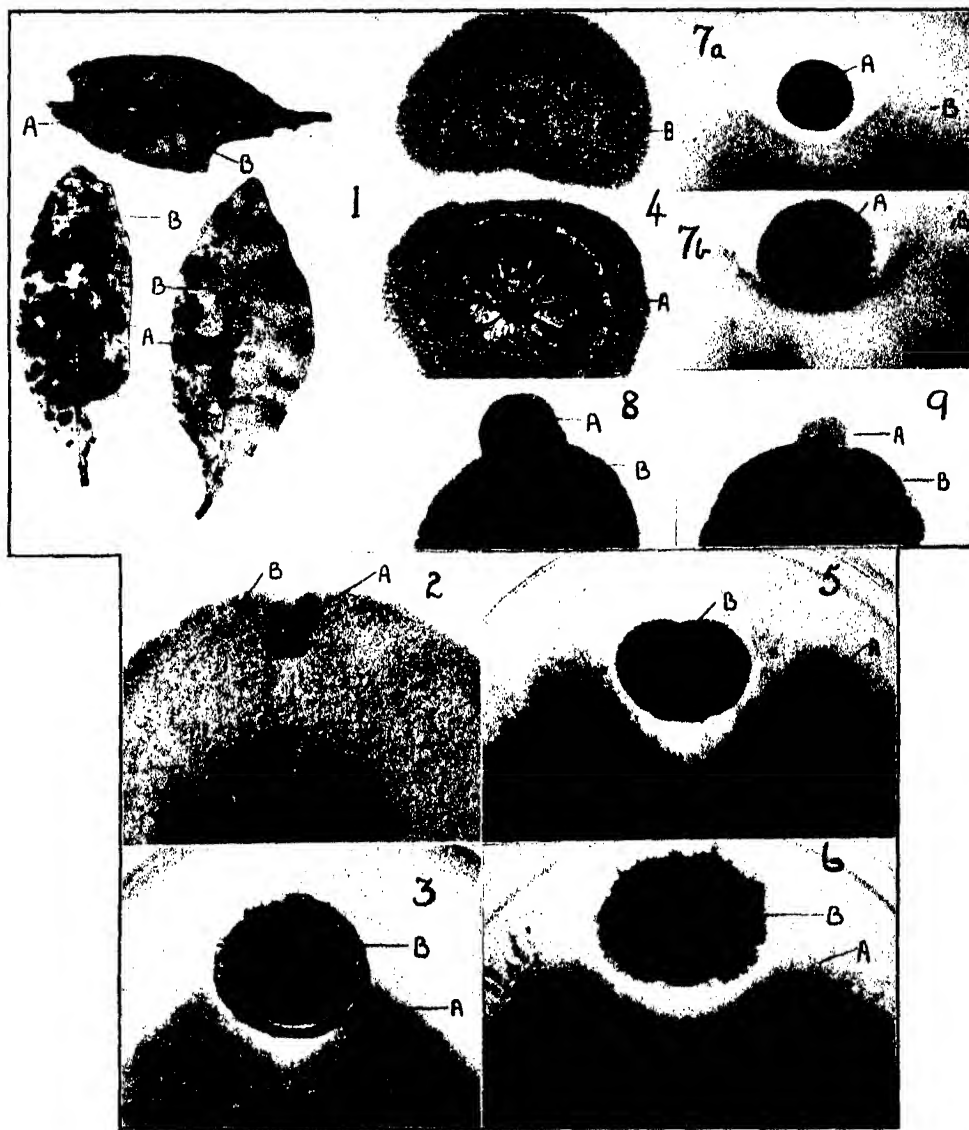




Sections of galls on *Fagus Moorei*.







Colonies of Sooty-mould Fungi.





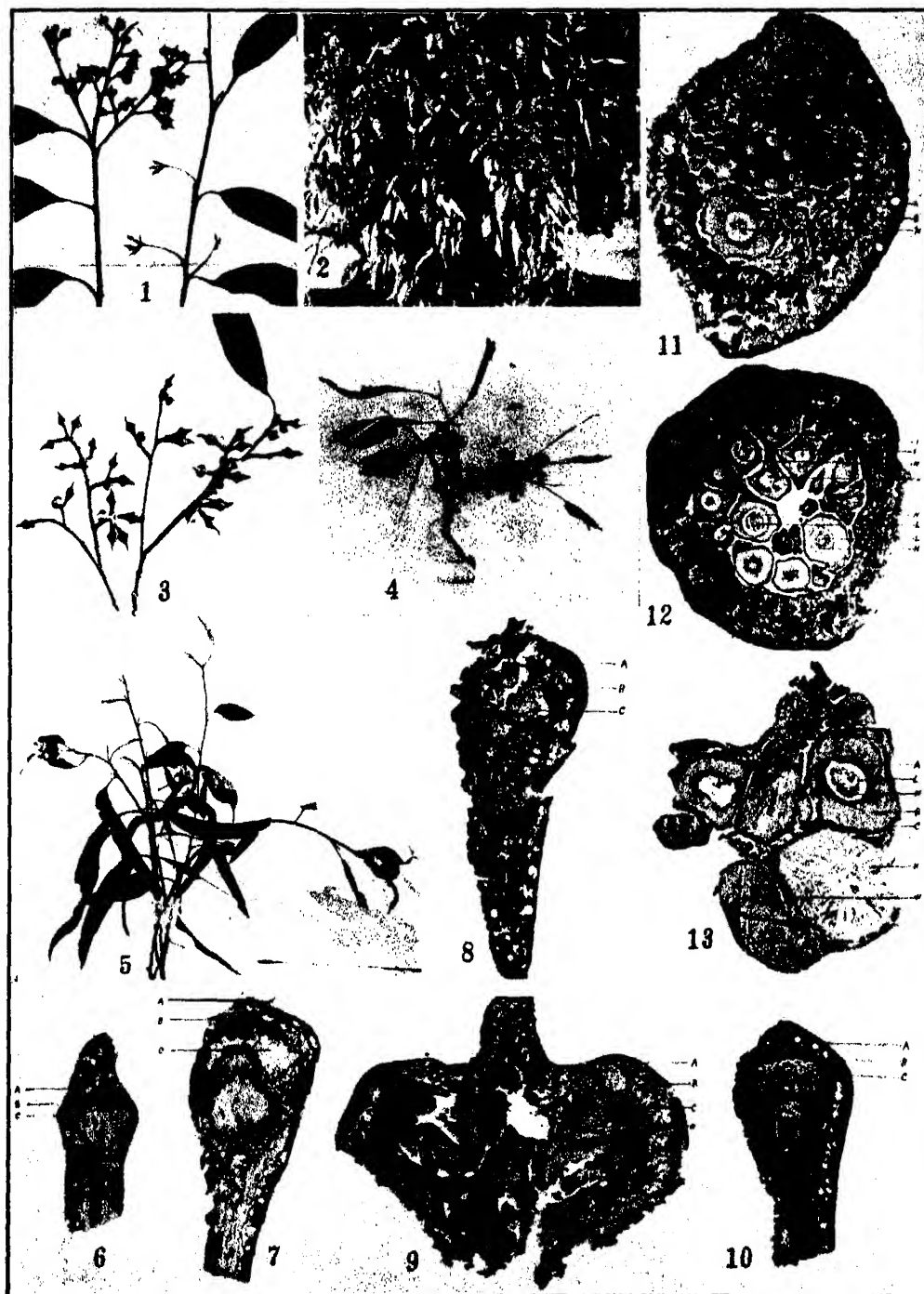
1.—*Eucalyptus gummifera* (Gaert.) Hochr. (= *E. corymbosa* Sm.)  
 2.—*Eucalyptus camaldulensis* Dehnh. (= *E. rostrata* Schlecht.)





*Drimys purpurascens*, n. sp.

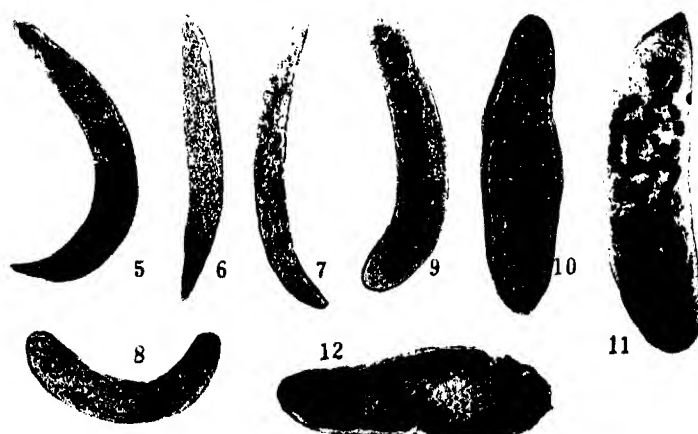
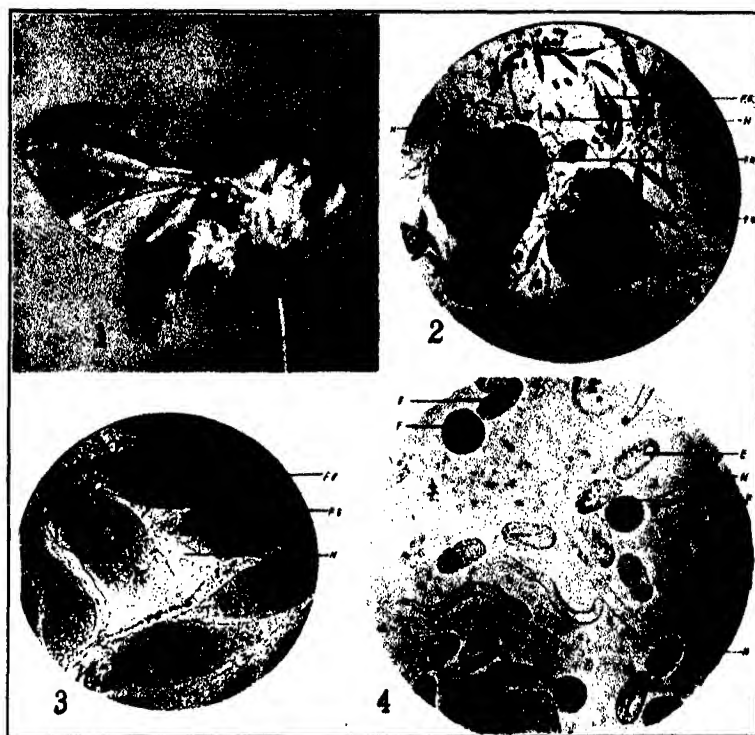




Galling of *Eucalyptus* species.

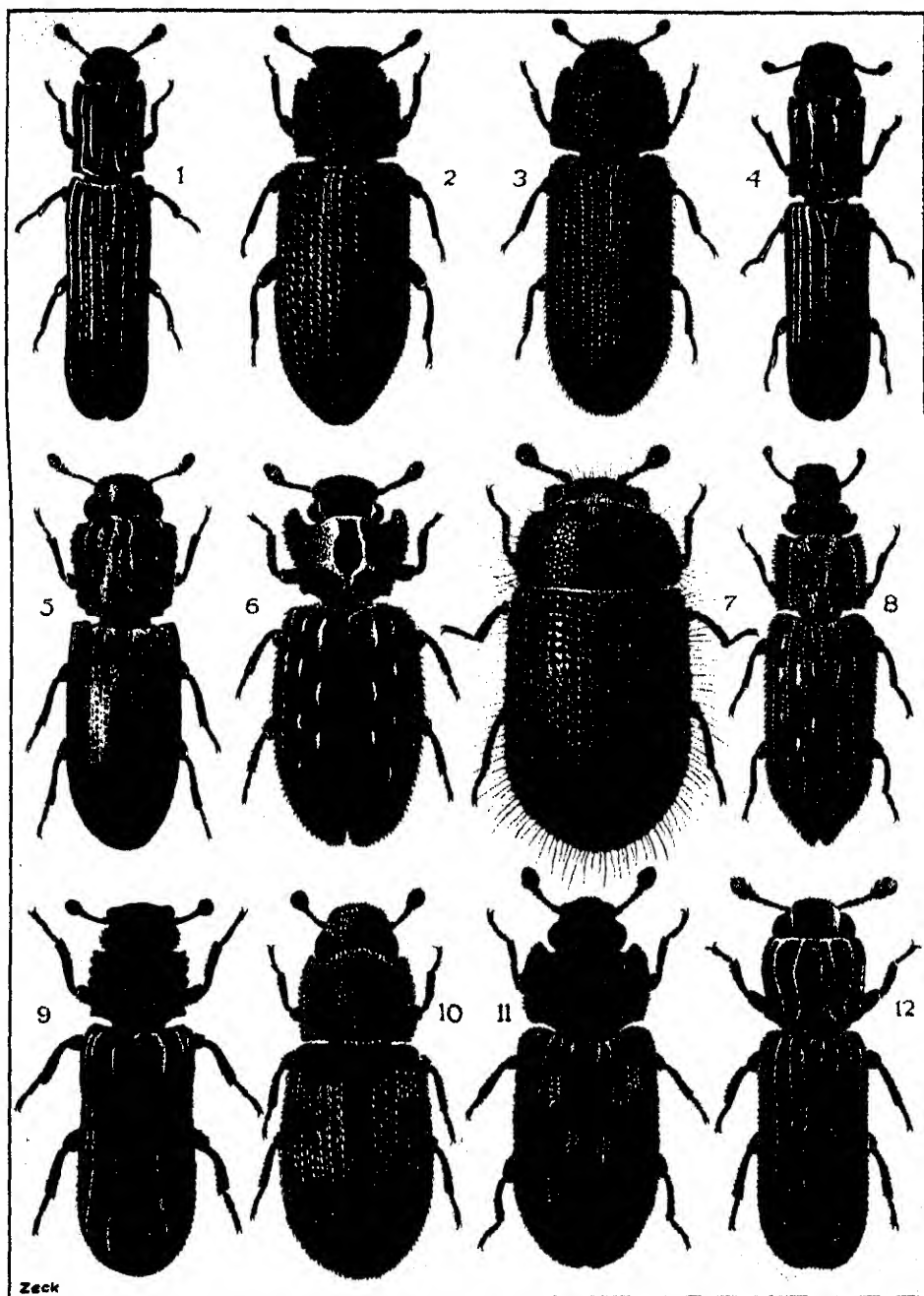






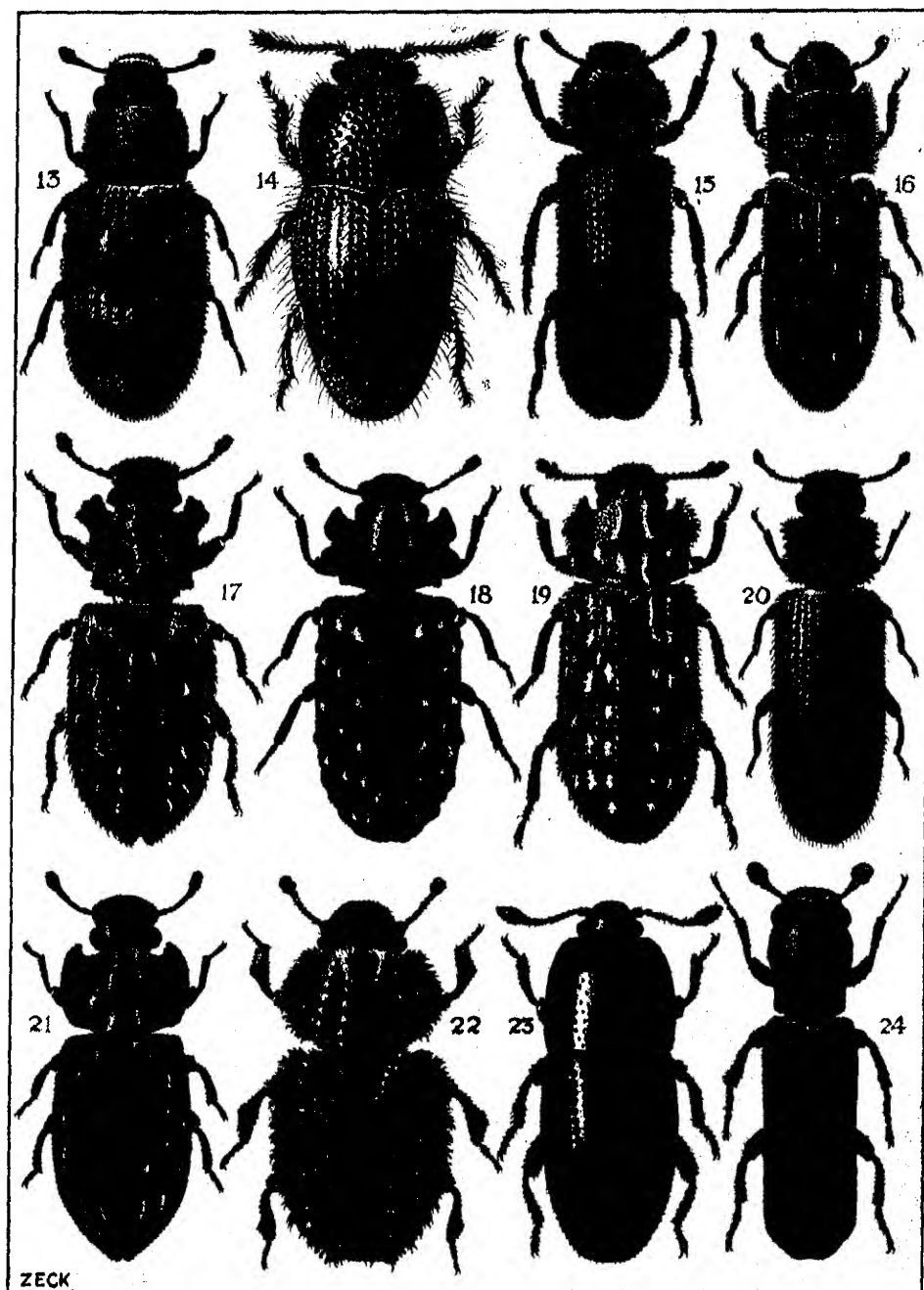
Fly and nematodes causing galls on Eucalypts.





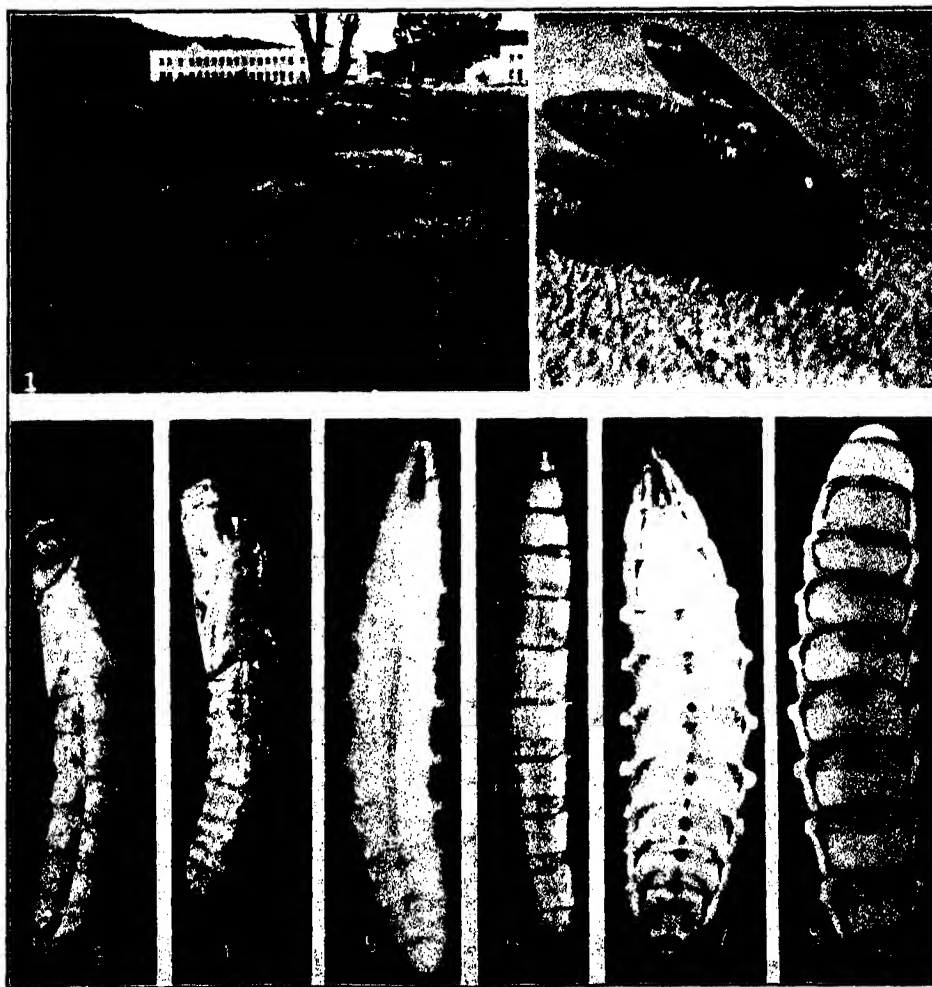
Australian Colydiidae.





Australian Colydidae.

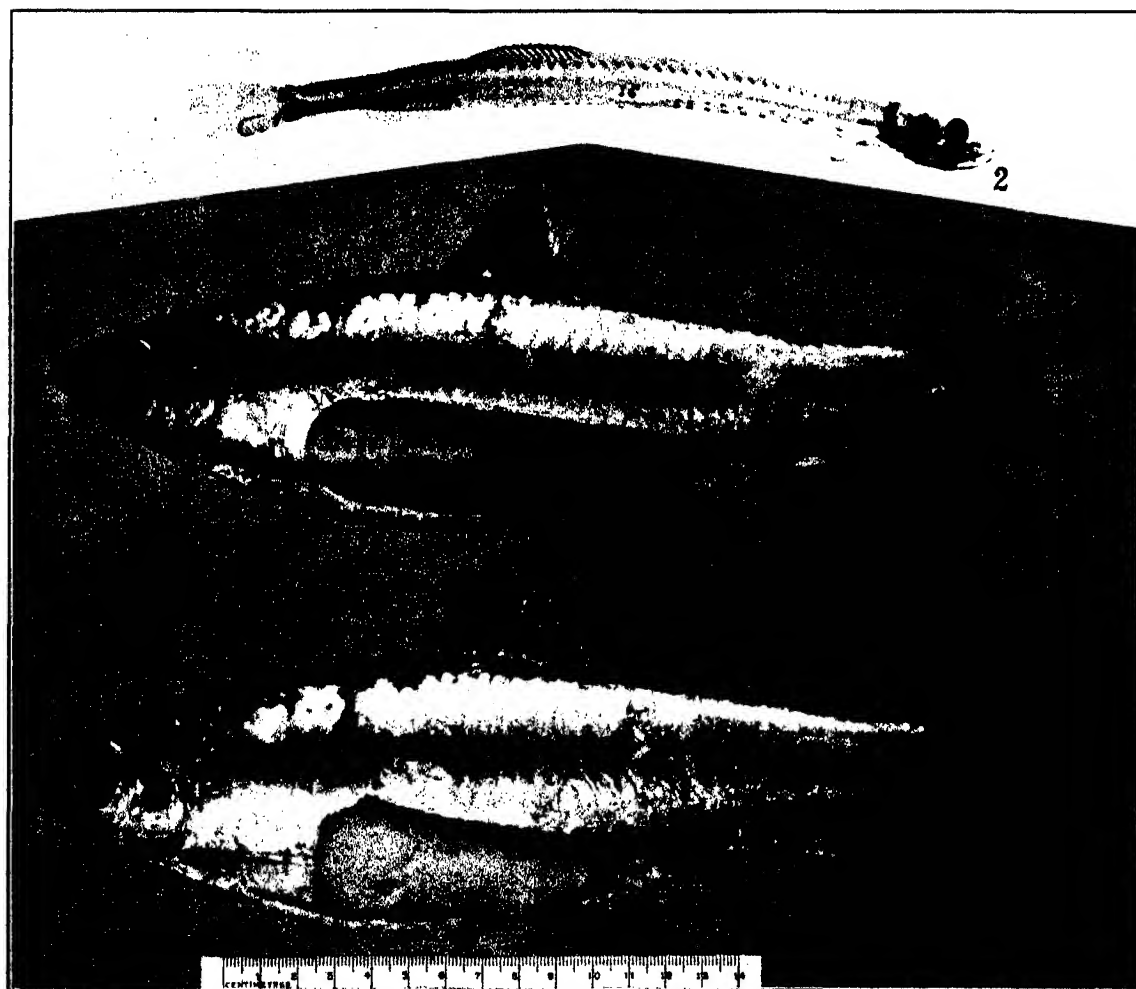




*Tabanus froggatti* (figs. 2, 3, 5, 6) and *T. neobasalis* (figs. 4, 7, 8).

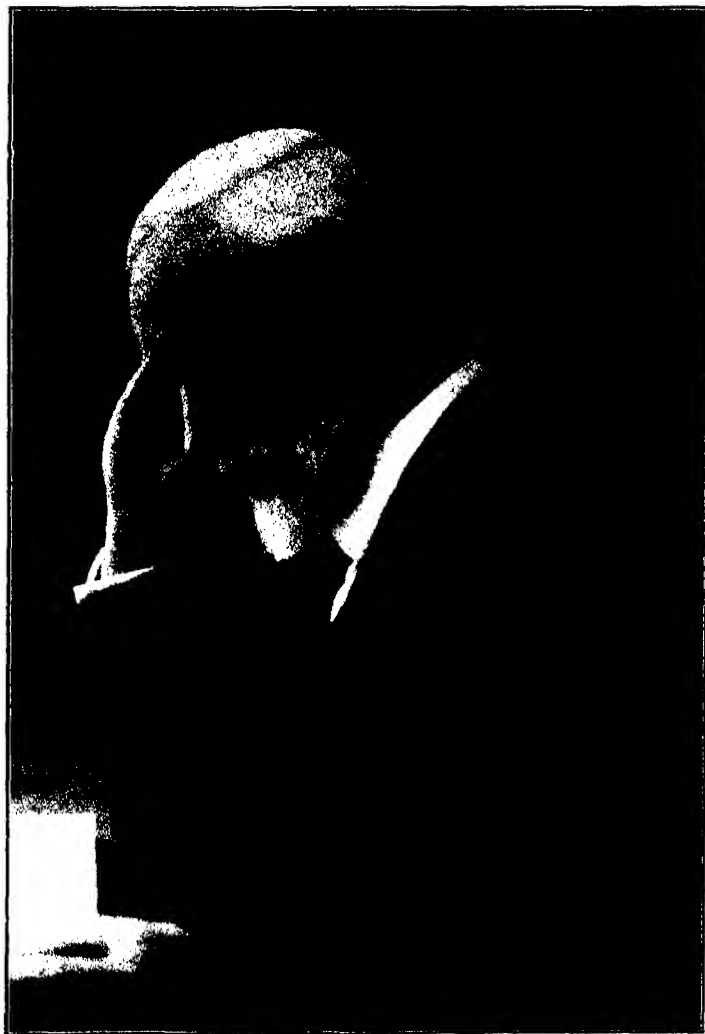






1, 2.—*Sardinops neopilchardus* (1, young; 2, larva). 3, 4.—*Potamalosia novae-hollandiae*.



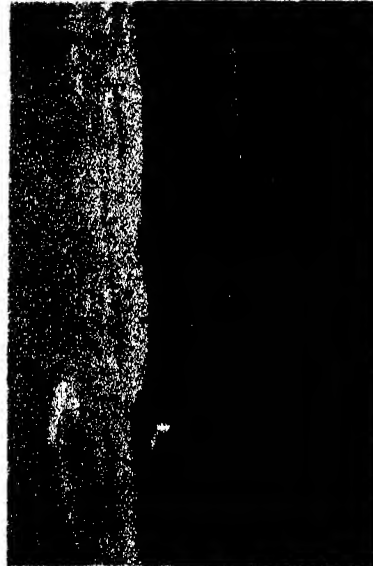


*A. H. Lucas*

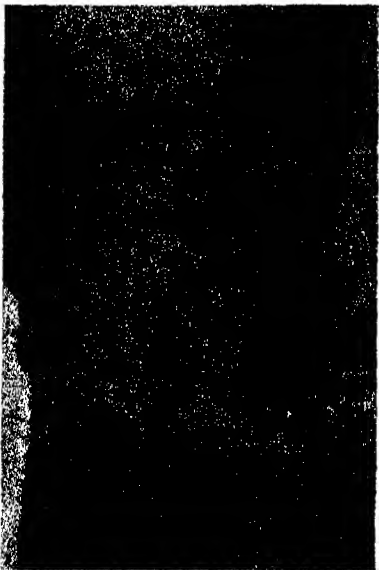




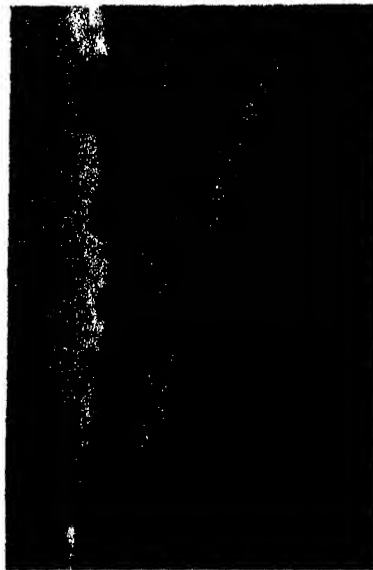
2



4



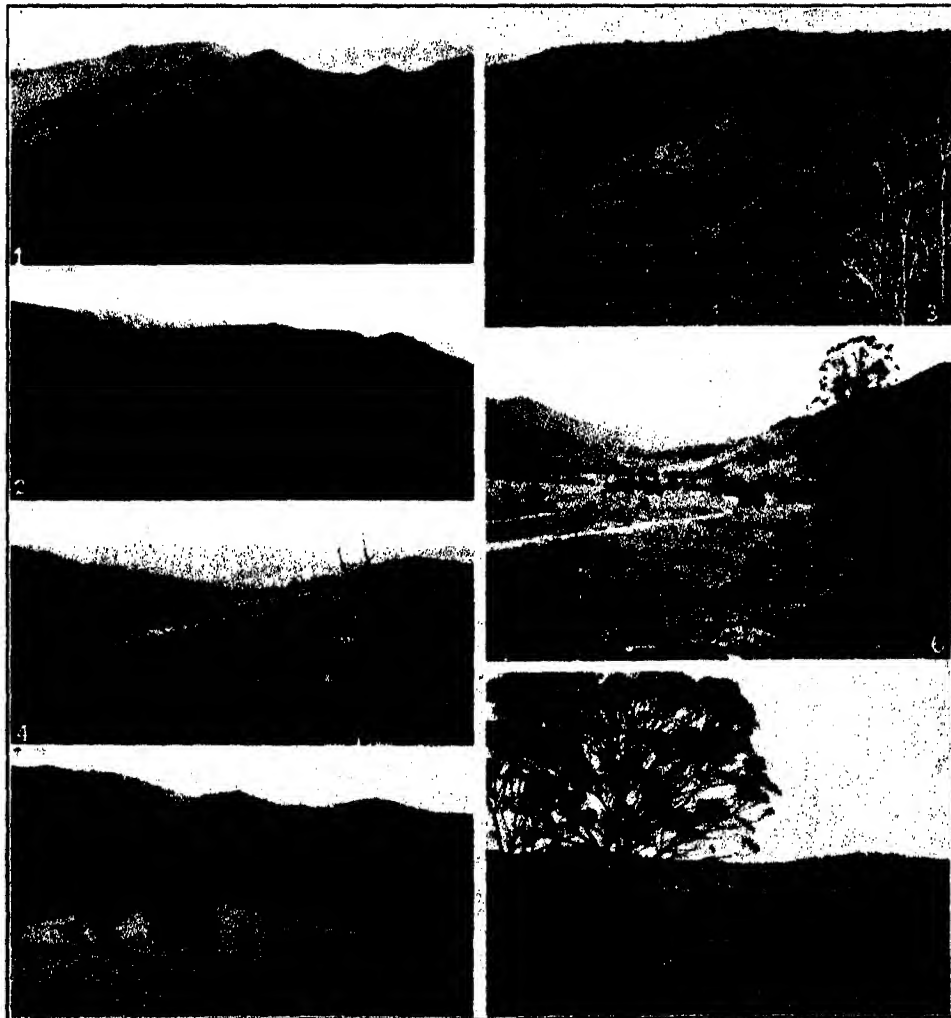
1



3

(Dufay Colour Process.)  
Landscapes in the Tamworth District of New South Wales, Australia.

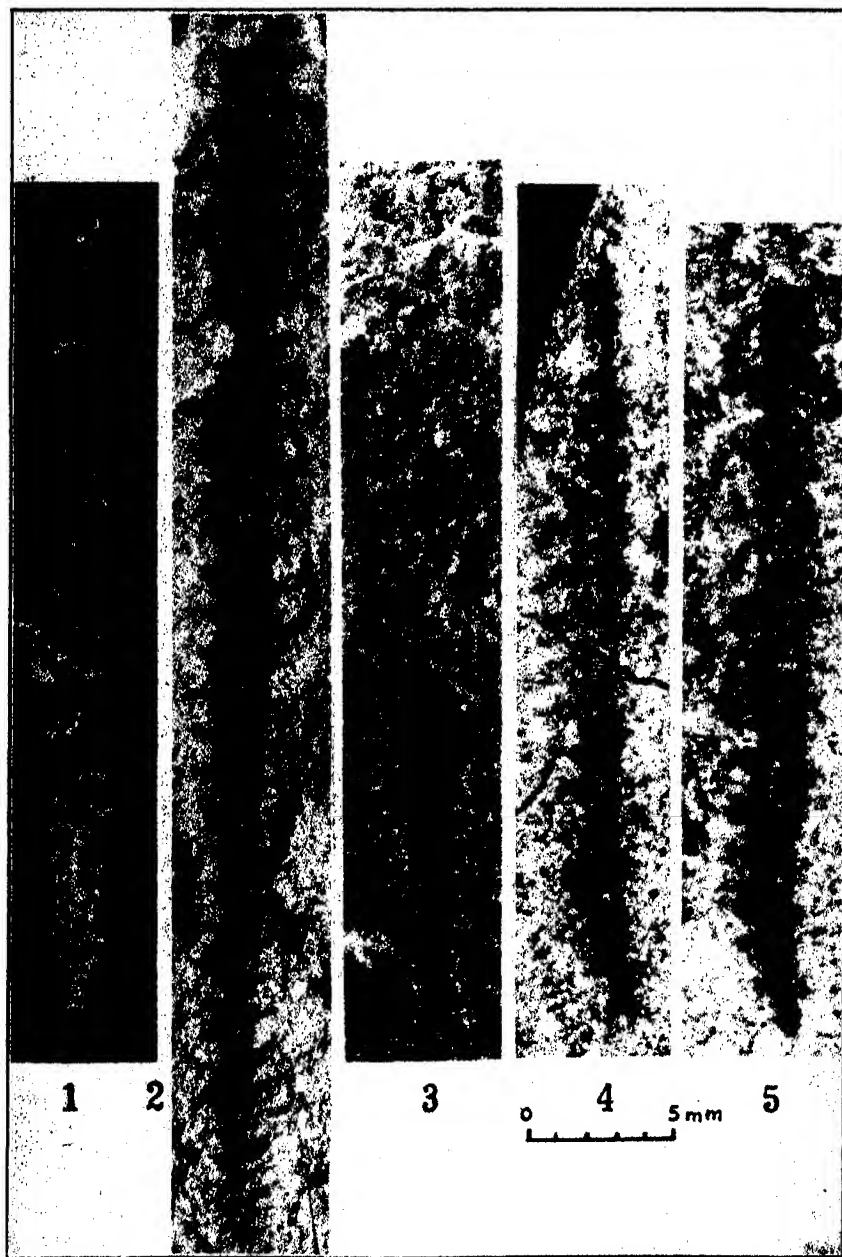




Upper Williams River and Barrington Tops Districts.



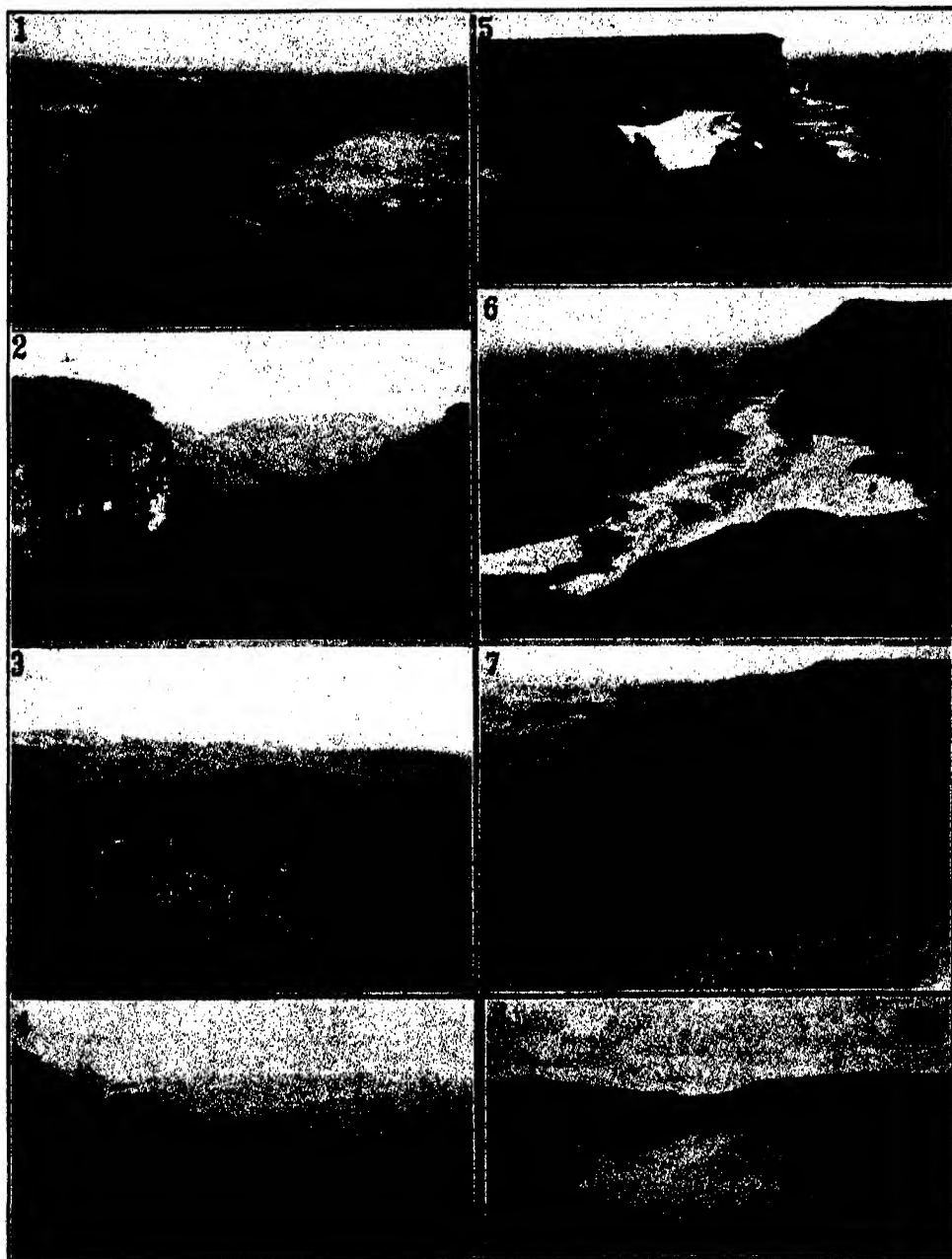




1, *Retlograptus yassensis*, n. sp.  
3, *Climacograptus tubuliferous*.

2, *R. pulcherrimus*.  
4, 5, *Monograptus flemingii*.





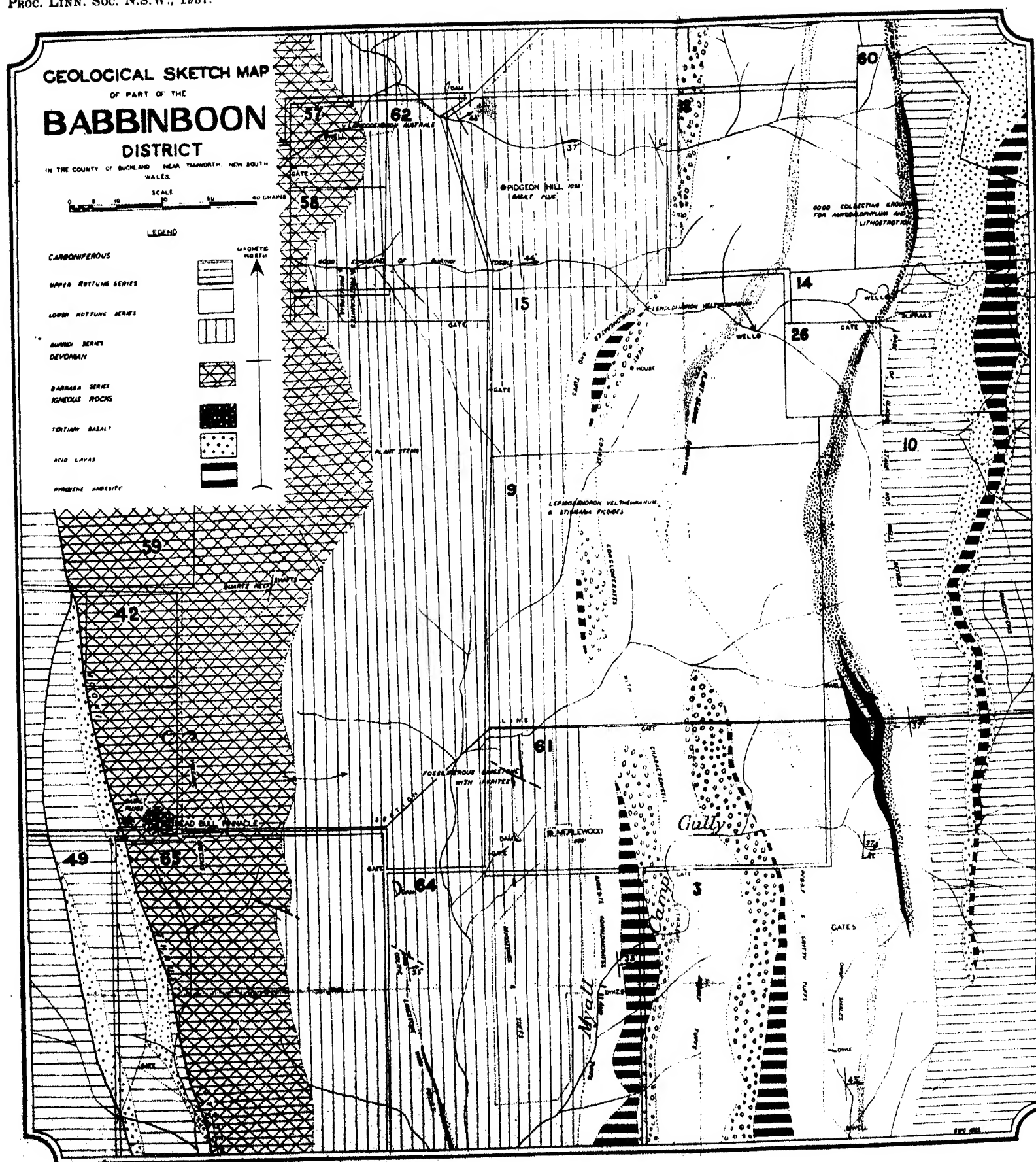
Vegetation of central coastal area of New South Wales.





Vegetation of central coastal area of New South Wales.









**I. A. R. I. 75.**

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